70
SEPT-DEC
1939

THE PHILIPPINE JOURNAL OF SCIENCE

VOLUME 70

SEPTEMBER TO DECEMBER, 1939

WITH 30 PLATES AND 145 TEXT FIGURES

MANILA
BUREAU OF PRINTING
1939

34494

THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science, Department of Agriculture and Commerce

[Entered at the Post Office at Manila, Philippines, as second-class matter.]

Exch.
Philippine Island
Bureau Science

CONTENTS

No. 1, September, 1939

[Issued October 6, 1939.]

No. 2, October, 1939

[Issued October 31, 1939.]

No. 3, November, 1939

[Issued October 31, 1939.]

No. 4, December, 1939

[Issued December 23, 1939.]

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 70 SEPTEMBER, 1939 NO. 1

THE FLEAS OF CHINA [1]

ORDER SIPHONAPTERA

By C. Y. LIU [2]

Of the Division of Entomology and Economic Zoölogy, University of Minnesota, and the Division of Entomology, National University of Chekiang, Hangchow

ONE HUNDRED AND THIRTY-TWO TEXT FIGURES

INTRODUCTION

Until the discovery of their rôle in the transmission of plague from rodents to man, the fleas were a neglected group of insects. The establishment of this relationship between man, rat, and flea was chiefly responsible for the intensification of the systematic and other lines of investigation on this small group of insects.

About 800 species are known from different parts of the world. Jordan (1928) reported that 46 species are known from England and 131 species from the United States. In a previous paper (1936) I have compiled another 70 species for China.

In the present paper attempts have been made to summarize our knowledge of the Chinese Siphonaptera to date and to bring together their descriptions. I have thus included keys to families, subfamilies, genera, and species, as well as descriptions of salient characters. For a detailed bibliography and specific distribution of Chinese fleas the reader is referred to the catalogue mentioned above. In this catalogue are mentioned 7 subfamilies

[1] Contribution No. 7 from the Division of Entomology, College of Agriculture, National University of Chekiang, Hangchow.

[2] Chinese form: Liu Chi-ying.

28729

belonging to 3 families. Owing to our increased knowledge of the group at present, it seems necessary to raise some subfamilies to family rank. Besides, there are a few additional species, and minor changes had to be made in the arrangement of some groups. Many of the illustrations included in this paper are adapted from the original authorities, and for economy of space the proportional distance between the spermatheca and the seventh sternite shown in the figure is often shortened.

The present study was begun in 1933 at the suggestion of Dr. Wm. A. Riley, Chief of the Division of Entomology and Economic Zoölogy, University of Minnesota, to whom I am indebted for helpful criticisms, much assistance, and constant encouragement throughout the progress of this work. Thanks are due Dr. H. E. Ewing, of the United States National Museum; to Dr. K. Jordan, of the Tring Zoölogical Museum; to Dr. J. Wagner, of the University of Belgrade; to Dr. I. Ioff, of the Microbiological Institute, Voroshilovsk; to Dr. Y. C. Hsü, of Yenching University; to Mr. F. S. Lee, now of the National Cotton Improvement Institute, and to Miss M. Y. Wu at Wuchang, for their kindness in loaning or supplying material for study. Several institutions, particularly Cornell University, Harvard University, and the University of Oklahoma, loaned specimens for study, and a number of persons, particularly Dr. C. E. Mickel, Mrs. M. C. Spriestersbach, and Dr. C. H. Yen, all of the University of Minnesota; Dr. C. H. Hoffmann, now of the Bureau of Entomology and Plant Quarantine; Mr. K. F. Chen, of the University of Nanking; and Mr. M. H. Feng, of the West Lake Provincial Museum, aided me in various ways, and it is a pleasure to acknowledge here their generous help and hearty coöperation.

HISTORY

The history of the Siphonaptera, taxonomically speaking, begins with the description of the cosmopolitan human flea, *Pulex irritans*, by Linnæus in his classical work, Systema Naturae.[3] The first Chinese species reported was a sand flea, recorded in 1894 by Blandford, who doubtfully identified it as *Tunga penetrans;* this species was later found by Jordan and Rothschild to be a different species, named in 1921 *Tunga cæcigena.* In 1910 Dampf described *Nycteridopsylla galba*, an interesting bat flea from Shanghai. The following year, 1911, was marked by

[3] Ed. 10 No. 1 (1750) 614.

a large crop of Chinese forms described by Jordan and Rothschild. In 1912 Rothschild discovered, besides two other species, a jigger flea, *Vermipsylla dorcadia,* the females of which are sedentary maggotlike creatures parasitic in the roedeer's nostrils, and the males lead an active life in the thick coat of the same animal. Little was done between 1913 and 1920, while the period from 1921 to the present has been one of great activity in the study of this group. The untimely death of the Honorable N. C. Rothschild in 1923 was undoubtedly a great loss to science in this field. Most of the Chinese forms were later discovered by Dr. Karl Jordan and to a lesser extent by Dr. Julius Wagner, both of these workers being leading world authorities on this order of insects. Dr. H. M. Jettmar's collection of Siphonaptera from Mongolia and Manchuria, and Mr. H. Stevens's collection on the Kelley-Roosevelt Expedition in Yunnan and Szechuan yielded a number of new genera and species and contributed much to our knowledge of the fleas of northern and western China. Up to the present 73 species have been described or recorded from China, distributed in 6 families, 8 subfamilies, and 29 genera (Table 1).

In Table 2 a complete list of the 73 species of Chinese fleas is given together with the collections in which the types of each species are deposited. Two new species and one new genus are included.

TAXONOMIC CHARACTERS

Head.—The head is divided by the antennal groove into an anterior and a posterior portion, known as the front and occiput, respectively. The lateral lower portion of the front beneath the eye is the gena, and its prolongation backwards, the genal process. The antennal groove is said to be closed if this genal process extends so far back as to meet the occiput, or open if it is short and widely separated from the occiput. The frontal margin may be entire or notched, forming the frontal tubercle. The eye may be present, absent, or rudimentary. The antenna at rest lies in the antennal groove, the dorsum or venter of which may be open or closed. It consists of three parts, the first segment (scape), the second segment (pedicel) and the distal part (club). The pedicel usually bears a number of bristles which may or may not extend beyond the club. The club is composed of nine segments, the degree of this segmentation being of taxonomic value as some

TABLE 1.—*Describers of Chinese fleas and species described.*

																															Total.
	Families.	Ceratophyllidæ.														Ctenopsyllidæ.					Ischnopsyllidæ.			Vermipsyllidæ.	Pulicidæ.				Hectopsyllidæ.		6
	Subfamilies.	Ceratophyllinæ.											Ctenophthalminæ.	Rhadinopsyllinæ.		Ctenopsyllinæ.				Neopsyllinæ.					Pulicinæ.				Echidnophaginæ.	Sarcopsyllinæ.	8
	Genera.	*Ceratophyllus.*	*Diamanus.*	*Oropsylla.*	*Amphalius.*	*Paraceras.*	*Aceratophyllus.*	*Paradoxopsyllus.*	*Ophthalmopsylla.*	*Frontopsylla.*	*Geusibia.*	*Amphipsylla.*	*Ctenophthalmus.*	*Stenischia.*	*Rectofrontia.*	*Stenoponia.*	*Palæopsylla.*	*Ctenopsyllus.*	*Pectinoctenus.*	*Neopsylla.*	*Ischnopsyllus.*	*Myodopsylla.*	*Nycteridopsylla.*	*Vermipsylla.*	*Ctenocephalides.*	*Archæopsylla.*	*Xenopsylla.*	*Pulex.*	*Echidnophaga.*	*Dermatophilus.*	29
Year.	Author.	SPECIES																													
1758	Linnæus																											1			1
1801	Bosc	1																													1
1803	Schrank	1																													1
1811	Schönherr																	1													1
1826	Curtis																								1						1
1835	Bouché																								1						1
1875	Westwood																												1		1
1893	Wagner																				1										1

1895	Baker		1																												1
1898	Wagner	1		1																											2
1903	Rothschild																										1				1
1907	Do	1																													1
1908	Wagner	1																													1
1909	Miyajima and Koidsumi							1																							1
1910	Dampf																						1								1
1911	Jordan and Rothschild	2	1			1	1					1				1				2						1					10
1912	Rothschild																			1				1							2
1915	Jordan and Rothschild								1	1																					2
1915	Rothschild																			1											1
1921	Jordan and Rothschild									1											1									1	3
1922	Do	1			1																										2
1923	Do				1					1					1																3
1927	Ioff								1	1		1																			3
1929	Jordan			1					1			2			4		1		1			1									11
1929	Wagner	2						1	1			1			2																7
1932	Jordan	1						1			1		3	1						2											9
1932	Wagner									1																					1
1933	Sugimoto																				1										1
1935	Liu					1																									1
1935	Hsü																				1										1
	Total number of species described	11	2	2	2	2	1	3	4	5	1	5	3	1	7	1	1	1	1	7	3	1	1	1	2	1	1	1	1	1	73

TABLE 2.—*List of Chinese species of fleas and collections in which they are deposited.*

Group.	Type collection.
1. Family Ceratophyllidæ Dampf, 1908.	
Subfamily Ceratophyllinæ Dampf, 1908.	
1. Genus *Ceratophyllus* Curtis, 1832 (*sensu lato*).	
1. (*Ceratophyllus*) *gallinæ* (Schrank), 1803	?
2. (*Ceratophyllus*) *sinicus* Jordan, 1932	Zool. Mus. Tring [a]
3. (*Monopsyllus*) *anisus* Rothschild, 1907	Do.
4. (*Nosopsyllus*) *fasciatus* (Bosc), 1801	?
5. (*Gerbillophilus*) *læviceps ellobii* Wagner, 1929.	Zool. Mus. USSR [b]
6. (*Callopsylla*) *kozlovi* Wagner, 1929	Do.
7. (*Callopsylla*) *dolabris* Jordan et Rothschild, 1911.	Zool. Mus. Tring
8. (*Callopsylla*) *kaznakovi* Wagner, 1929	Zool. Mus. USSR
9*a*. (*Citellophilus*) *tesquorum mongolicus* Jordan et Rothschild, 1911.	Zool. Mus. Tring
9*b*. (*Citellophilus*) *tesquorum sungaris* Jordan, 1929.	Do.
9*c*. (*Citellophilus*) *tesquorum famulus* Jordan et Rothschild, 1911.	Do.
10. (?) *phæopis* Jordan et Rothschild, 1911.	Do.
11. (?) *sparsilis* Jordan et Rothschild, 1922.	Do.
2. Genus *Diamanus* Jordan, 1933.	
12. *mandarinus* (Jordan et Rothschild), 1911.	Do.
13. *montanus* (Baker), 1895	U. S. Nat. Mus.[c]
3. Genus *Oropsylla* Wagner et Ioff, 1926.	
14*a*. *silantiewi silantiewi* (Wagner), 1898	Wagner Coll. (?)
14*b*. *silantiewi crassus* (Jordan et Rothschild), 1911.	Zool. Mus. Tring
15. *elana* Jordan, 1929	Do.
4. Genus *Amphalius* Jordan, 1933.	
16. *runatus* (Jordan et Rothschild), 1923	Do.
17. *clarus* (Jordan et Rothschild), 1922	Do.
5. Genus *Paraceras* Wagner, 1916.	
18. *crispus* (Jordan et Rothschild), 1911	Zool. Mus. Tring
19. *sinensis* (Liu), 1935	U. S. Nat. Mus.
6. Genus *Neoceratophyllus* gen. nov.	
20. *trispinosus* sp. nov.	Liu Coll.[d]

[a] England.
[b] Akademy of Sciences, Leningrad, USSR.
[c] Washington, D. C.
[d] Division of Entomology, National University of Chekiang, Hangchow.

TABLE 2.—*List of Chinese species of fleas and collections in which they are deposited*—Continued.

Group.	Type collection.
7. Genus *Aceratophyllus* Ewing, 1929.	
21. *euteles* (Jordan et Rothschild), 1911	Zool. Mus. Tring
8. Genus *Paradoxopsyllus* Miyajima et Koidsumi, 1909.	
22. *curvispinus* Miyajima et Koidsumi, 1909.	?
23. *custodis* Jordan, 1932	Zool. Mus. Tring
24. *conveniens* Wagner, 1929	Zool. Mus. USSR
9. Genus *Ophthalmopsylla* Wagner et Ioff, 1926.	
25. *præfectus pernix* Jordan, 1929	Zool. Mus. Tring
26. *kukuschkini* Ioff, 1927	Zool. Mus. USSR
27. *jettmari* Jordan, 1929	Zool. Mus. Tring
28. *kiritschenkoi* Wagner, 1929	Zool. Mus. USSR
10. Genus *Frontopsylla* Wagner et Ioff, 1926.	
29. *elata botis* Jordan, 1929	Zool. Mus. Tring
30*a*. *luculenta luculenta* (Jordan et Rothschild), 1923.	Do.
30*b*. *luculenta parilis* Jordan, 1929	Do.
31. *wagneri* Ioff, 1927	Zool. Mus. USSR
32. *hetera* Wagner, 1932	?
33*a*. *spadix spadix* (Jordan et Rothschild), 1921.	Zool. Mus. Tring
33*b*. *spadix cansa* Jordan, 1932	Do.
11. Genus *Geusibia* Jordan, 1932.	
34. *torosa* Jordan, 1932	Do.
12. Genus *Amphipsylla* Wagner, 1908.	
35. *tuta* Wagner, 1929	Zool. Mus. USSR
36. *aspalacis* Jordan, 1929	Zool. Mus. Tring
37. *casis* Jordan et Rothschild, 1911	Do.
38. *mitis* Jordan, 1929	Do.
39. *vinogradovi* Ioff, 1927	Zool. Mus. USSR
Subfamily Ctenophthalminæ Rothschild, 1915.	
13. Genus *Ctenophthalmus* Kolenati, 1857.	
40. *parcus* Jordan, 1932	Zool. Mus. Tring
41. *yunnanus* Jordan, 1932	Do.
42. *dinormus* Jordan, 1932	Do.
Subfamily Rhadinopsyllinæ Wagner, 1930.	
14. Genus *Stenischia* Jordan, 1932.	
43. *mirabilis* Jordan, 1932	Do.
15. Genus *Rectofrontia* Wagner et Argyropulo, 1934.	
44. *dahurica* (Jordan et Rothschild), 1923.	Do.
45. *tenella* (Jordan), 1929	Do.
46. *dives* (Jordan), 1929	Do.

TABLE 2.—*List of Chinese species of fleas and collections in which they are deposited*—Continued.

Group.	Type collection.
47. *jaonis* (Jordan), 1929	Zool. Mus. Tring
48. *insolita* (Jordan), 1929	Do.
49. *accola* (Wagner), 1929	Zool. Mus. USSR
50. *vicina* (Wagner), 1929	Do.
2. Family Ctenopsyllidæ Baker, 1905.	
Subfamily Ctenopsyllinæ Wagner, 1927.	
16. Genus *Stenoponia* Jordan et Rothschild, 1911.	
51. *cœlestis* Jordan et Rothschild, 1911	Zool. Mus. Tring
17. Genus *Palæopsylla* Wagner, 1902.	Do.
52. *remota* Jordan, 1929	Do.
18. Genus *Ctenopsyllus* Kolenati, 1863.	
53. *segnis* (Schönherr), 1811	?
19. Genus *Pectinoctenus* Wagner, 1929.	
54. *adalis* Jordan, 1929	Zool. Mus. Tring
Subfamily Neopsyllinæ Oudemans, 1909.	
20. Genus *Neopsylla* Wagner, 1902.	
55. *bidentatiformis* (Wagner), 1893	Wagner Coll. (?)
56. *anoma* Rothschild, 1912	Zool. Mus. Tring
57. *aliena* Jordan et Rothschild, 1911	Do.
58. *compar* Jordan et Rothschild, 1911	Do.
59. *stevensi* Rothschild, 1915	Do.
60. *specialis* Jordan, 1932	Do.
61. *honora* Jordan, 1932	Do.
3. Family Ischnopsyllidæ Wahlgren, 1907.	
21. Genus *Ischnopsyllus* Westwood, 1833.	
62. *comans* Jordan et Rothschild, 1921	Do.
63. *needhamia* Hsü, 1935	Hsü Coll.[e]
64. *tateishii* Sugimoto, 1933	Sugimoto Coll.[f]
22. Genus *Myodopsylla* Jordan et Rothschild, 1911.	
65. *trisellis* Jordan, 1929	Zool. Mus. Tring
23. Genus *Nycteridopsylla* Oudemans, 1906.	
66. *galba* Dampf, 1910	Königsberg Mus.[g] or Dampf Coll.
4. Family Vermipsyllidæ Wagner, 1889.	
24. Genus *Chætopsylla* Kohaut, 1903.	
67. *hangchowensis* sp. nov.	Liu Coll.
25. Genus *Vermipsylla* Schimkewitsch, 1885.	
68. *dorcadia* Rothschild, 1912	Zool. Mus. Tring

[e] Y. C. Hsü Collection, Bureau of Entomology, Hangchow.
[f] Veterinary Laboratory, Taihoku Imperial University, Formosa.
[g] Königsberg, Prussia.

TABLE 2.—*List of Chinese species of fleas and collections in which they are deposited*—Continued.

Group.	Type collection.
5. Family Pulicidæ Taschenberg, 1880.	
Subfamily Pulicinæ Tiraboschi, 1904.	
26. Genus *Ctenocephalides* Stiles et Collins, 1930.	
69. *canis* (Curtis), 1826	?
70. *felis* (Bouche), 1835	?
27. Genus *Archæopsylla* Dampf, 1908.	
71. *sinensis* Jordan et Rothschild, 1911	Zool. Mus. Tring
28. Genus *Xenopsylla* Glinkewicz, 1907.	
72. *cheopis* (Rothschild), 1903	Do.
29. Genus *Pulex* Linnæus, 1758.	
73. *irritans* Linnæus, 1758	Linnæan Society [h]
6. Family Hectopsyllidæ Baker, 1904.	
Subfamily Echidnophaginæ Wagner, 1927.	
30. Genus *Echidnophaga* Oliff, 1886.	
74. *gallinacea* (Westwood), 1875	?
Subfamily Sarcopsyllinæ Wagner, 1927.	
31. Genus *Dermatophilus* Guerin, 1838.	
75. *cæcigena* (Jordan et Rothschild), 1921	Zool. Mus. Tring

[h] London, England.

species have their club partially segmented only on the posterior border instead of completely segmented all the way around. In a number of genera the gena bears a genal comb of spines arranged either horizontally or vertically. Occasionally the anterior end of the head is provided on each side with a pair of anteroventral (oral) flaps which are in reality modified genal spines. Setæ are present on the head in definite rows which are named according to their site, such as frontal row, prefrontal row, ocular row, and occipital rows. The maxillæ, as a rule, are triangular, with an acute apex. The length and the number of joints of the labial palpus are diagnostic of genera.

Thorax.—The pro-, meso-, and metathorax are formed of a dorsal portion (notum) and a ventral portion (sternum). In many genera the pronotum bears a pronotal comb. The prosternum is undivided, but the lateral portions of the meso- and metasterna are divided by an internal, rodlike, sclerotized thickening extending upward from the insertion of the coxa, into an anterior and a posterior part, the sternal and the meral portion (epimeron). The sternal portion is further divided into an upper part, the episternum, and a lower part, the sternum. The epimeron of the metathorax is broad, overlap-

ping the abdomen and supplanting the sternite of the first abdominal segment. There is a spiracle on both sides of each thoracic segment, the third being located at the upper edge of the metepimeron. In general the thorax is well developed, but in a few cases it is greatly reduced. Setæ are usually present in rows on the notum and metepimeron. The three pairs of legs are rather specialized. The coxa is a broad plate with or without spinelets and longish hairs. The presence or absence of hairs on the inner and outer surfaces of the femur are also important in classification. The tibia widens out at its distal

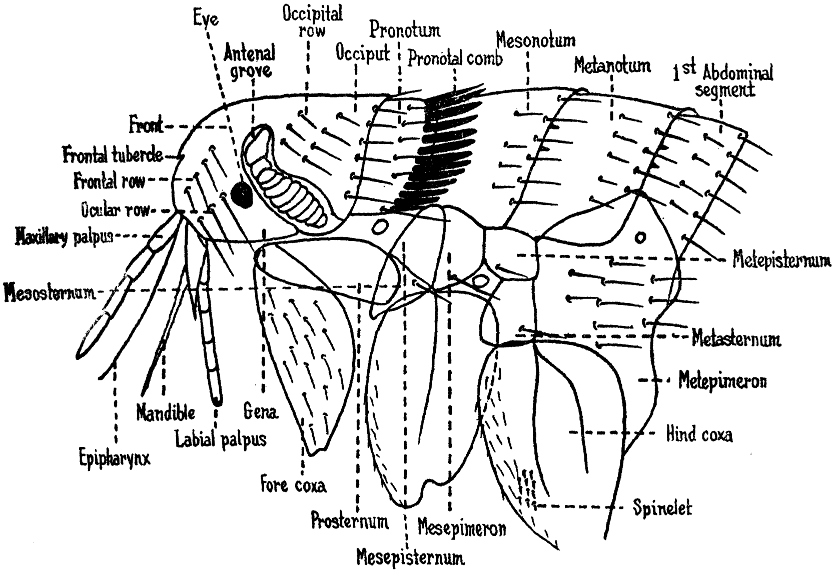


FIG. 1. Head and thorax of a flea.

extremity, and its strong bristles along the dorsum may be in a comb, rows, pairs, or even triples. The last tarsal segments are provided with lateral pairs of plantar bristles, the number and arrangement of which are of taxonomic value. Some fleas have the first pair of plantar bristles moved ventrad in between the second pair, while others do not.

Abdomen.—The abdomen bears ten segments. Spiracles are present in the pleural membrane on each side of the second to the seventh abdominal segments. The abdominal segments are clothed with setæ or bristles and sometimes have small apical teeth and combs of spines. The first abdominal sternite is always missing.

Modified segments.—The seventh tergite bears on or near its dorsoapical margin on each side one or more stout antepygidial bristles, *ant b,* sometimes arising from a conelike process. Behind these bristles is a sensory organ, known as the pygidium, *pyg,* which is carried on the dorsal portion of the ninth tergite, and separated from the seventh tergite by the dorsal part of the eighth tergite which contains the eighth or last spiracle. The size of the spiracle (stigma), particularly that of the eighth abdominal tergite and of the metathorax, is useful in the differentiation of certain genera.

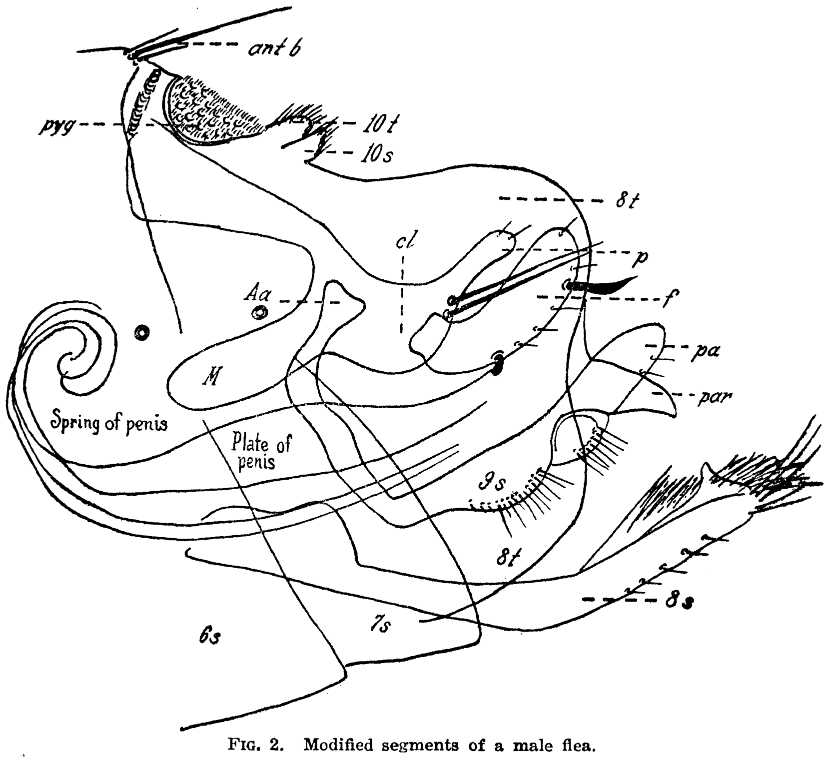


FIG. 2. Modified segments of a male flea.

Male.—The eighth tergite, 8*t,* is a broad plate which conceals the ninth segment. The eighth sternite, 8*s,* is usually rodlike and sometimes bears a membranous flap. The structure of the clasping organs is a matter of much concern in describing species. The clasping organs are evolved from the ninth abdominal segment and are divided into the upper and lower claspers. In general the upper claspers, which are developed

from the ninth tergite, comprise three parts: a more or less broad, irregularly shaped plate or body of the clasper *cl*, a long process extending cephaloventrad and known as the manubrium, *m*, and a pair of movable fingers or exopodites, *f*, each articulated to the plate. In some species there may be two or more movable fingers on each side. Above and anterior to the insertion of the movable finger, the body of the clasper may be prolonged to form one, and sometimes two, conelike processes, *p*. At or near the point of insertion of the finger there are usually two stout acetabular bristles. The lower clasper, 9*s*, which is derived from the ninth sternite, frequently appears as a boomerang on side view. It consists of an internal anterior arm (vertical arm), *Aa*, and an external posterior arm (horizontal arm), *pa*. The former extends upward to the base of the manubrium lying on its outer side and exhibits different degrees of curvature, and the latter may project distally from the end of the abdomen and is sometimes divided into lobes or fused with its fellow of the opposite side. During the act of copulation the penis is protruded between the upper and lower claspers. The ceiling of the spring of the penis may be incomplete, complete, or double. The paramere, *par*, of the penis is usually membranous. Posterior to the pygidium are two bristled structures known as the tenth tergite, 10*t*, and tenth sternite, 10*s* (anal tergite or sternite).

Female.—The apex of the seventh sternite, 7*s*, is characteristic of the species and is therefore of great taxonomic value. The eighth tergite, 8*t*, is a broad plate, its lateral portion expanding to form a broad lobe which conceals the ninth tergite and the ninth sternite between which the vulva is located. The eighth sternite, 8*s*, is usually an elongated arm situated ventrad between the seventh sternite and the eighth tergite. The tenth tergite, 10*t*, and the tenth sternite, 10*s*, appear as two small flaps posterior to the pygidium. The tenth tergite bears a small bristled process known as the stylet, *sty*. The anus in both sexes is located between the tenth tergite and the tenth sternite. Some accessory reproductive organs are almost as valuable in the determination of species in the female as the claspers are in the male. This is especially true of the spermatheca (receptaculum seminis), the bursa copulatrix, and the accessory ducts. The spermatheca, *sp*, is made up of a dilated portion or head (body) and a contracted portion or tail (appendix). Attached to the apex of the head is the tortuous coil of the duct of the

spermatheca (ductus receptaculi seminis). Its distal part, which is connected with the head, is in some species dilated and known as pars dilatata, and its proximal part empties into the bursa copulatrix which receives the penis during copulation. The bursa copulatrix is usually divided into three parts, a dilated upper part, a middle part usually more sclerotized than the rest, and a lower part or duct. The upper part is connected to the duct of the spermatheca on the one hand, and is sometimes connected to a blind duct known as ductus obturatorius on the other hand. The spermatheca and part of the bursa copulatrix are more or less sclerotized and are therefore easily recognized. The ducts are, however, more difficult to see and study.

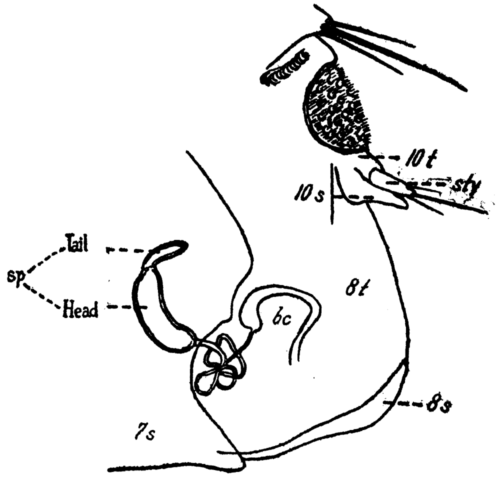


FIG. 3. Modified segments of a female flea.

Order SIPHONAPTERA

Small, wingless, laterally compressed insects, usually with dark-colored, bristly body and legs, heavily sclerotized; ectoparasitic in the adult stage on mammals, or occasionally on birds. Head small, closely articulated with thorax. Antennæ short and thick, with two large basal joints and an oval or elongate apical portion reposing in grooves. Eyes present or absent. Mouth parts fitted or piercing and sucking, mandibles setiform, maxillæ bladelike; both pairs of palpi well developed. Thorax small, composed of three freely movable segments. Legs large, stout; coxæ very large, tarsi 5-jointed, with stout claws. Abdomen large, composed of ten segments. Metamorphosis complete; larvæ elongate, cylindrical, legless, with well-developed head and biting mouth parts; free living. Pupæ enclosed in cocoons. (Modified from Brues and Melander, 1932).

Key to the families of Siphonaptera.

1. Thorax not reduced, three thoracic tergites together longer than first abdominal tergite. Abdomen of gravid female only slightly, if at all, distended .... 2.

Thorax considerably reduced, three thoracic tergites together shorter than first abdominal tergite. Abdomen of gravid female greatly distended. HECTOPSYLLIDÆ.

2. Clasper of male with one movable finger on each side. Hind coxæ usually without spinelets on inner side. Typical abdominal tergites usually with at least two rows of setæ .... 3.
Clasper of male with two movable fingers on each side. Hind coxæ with spinelets on inner side. Typical abdominal tergites with but a single row of setæ .... PULICIDÆ.
3. With or without comb, in latter case antepygidial bristles always present in both sexes. Abdominal tergites provided with tiny apical teeth ...... 4.
With neither comb nor antepygidial bristles. Abdominal tergites without tiny apical teeth .... VERMIPSYLLIDÆ.
4. Vertical suture between bases of antennal grooves absent or rudimentary. Abdomen without combs. Head without preoral flaps. Abdomen of female with only one spermatheca .... CERATOPHYLLIDÆ.
Vertical suture between bases of antennal grooves distinctly present. Abdomen sometimes with combs. Head sometimes with preoral flaps. Abdomen of female often with two spermathecæ .... 5.
5. Head without two preoral flaps on each side. Mainly on rodents, not on bats .... CTENOPSYLLIDÆ.
Head with two preoral flaps on each side. On bats ...... ISCHNOPSYLLIDÆ.

1. Family CERATOPHYLLIDÆ Dampf, 1908

Head with or without genal comb. Eyes present or absent. Vertical suture between bases of antennal grooves absent or rudimentary. Preoral flaps lacking. Thorax not strongly shortened, its tergites together longer than first abdominal tergite. Pronotal comb often present. Abdomen without combs, with tiny apical teeth on some tergites, with more than a single row of bristles to each typical abdominal tergite. Antepygidial bristles present in both sexes. Clasper of male with one movable finger. Abdomen of gravid female only slightly distended, provided with only one spermatheca. The largest family of the order Siphonaptera.

Key to the subfamilies of Ceratophyllidæ.

1. Head without genal comb .... CERATOPHYLLINÆ.
Head with genal comb .... 2.
2. Genal comb horizontal, composed of three nearly equal spines. Both sexes with antepygidial bristles .... CTENOPHTHALMINÆ.
Genal comb obliquely vertical, composed of four to six spines. Male with antepygidial bristles .... RHADINOPSYLLINÆ.

Subfamily CERATOPHYLLINÆ Dampf, 1908

Head without genal comb, with a frontal tubercle. Eyes present or absent. Antennal groove usually widely open in both

sexes. As a rule, antepygidial bristles present in both sexes; females in general with three large antepygidial bristles, males with one large antepygidial bristle on each side.

Key to the genera of Ceratophyllinæ.

1. Ocular bristle situated below upper margin of eye and in front of eye. Front without internal sclerotized rod before eye.............................. 2.
   Ocular bristle situated above upper margin of eye and near margin of antennal groove. Front with internal sclerotized rod before eye, its anterior apex located near midbristle of ocular row and winding upwards, disappearing at eye, and terminating at apex of genal process .... 8.
2. First pair of plantar bristles shifted ventrad and located almost in between second pair. Finger of male with ventral process near base.... 3.
   First pair of plantar bristles not, or only slightly, shifted ventrad, not located in between second pair... 4.
3. Inner surface of mid- and hind coxæ without longish thin bristles from base to apex. Fore femur with lateral bristle on outer surface. 7*t* not projecting medianly in between two sets of antepygidial bristles. Male, finger with one ventral process. Ejaculatory duct normal. Female, stylet with one bristle at apex. Division between head and tail of spermatheca distinct.............................. *Aceratophyllus* Ewing.
   Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Fore femur with several small lateral bristles on outer surface. 7*t* slightly projecting medianly in between two sets of antepygidial bristles. Male, finger with two ventral processes. Ejaculatory duct deeply curved twice. Female, stylet with numerous bristles at rounded apex. Division between head and tail not distinct. *Amphalius* Jordan.
4. Inner surface of mid- and hind coxæ without longish thin bristles. 7*t* with a short median process in between two sets of antepygidial bristles .... *Neoceratophyllus* gen. nov.
   Inner surface of mid- and hind coxæ with longish thin bristles. 7*t* as a rule without median process in between two sets of antepygidial bristles .... 5.
5. Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Labial palpus reaching to, or beyond, apex of fore trochanter .... 6.
   Inner surface of mid- and hind coxæ with longish thin bristles at most in apical half. If bristles are present on basal half, the hind part of 8*t* of male is widened to form a dorsal projection and the anal sternite is longitudinally split into two lobes and is much longer than the anal tergite. Labial palpus, except in the subgenus *Citellophilus* and in the section *Gerbillophilus*, reaching, or not reaching, to apex of forecoxa...................................... *Ceratophyllus* Curtis. (*sensu lato*).
6. Outer surface of fore femur usually without lateral bristles. Male, bristles of second antennal segment reaching beyond apex of club. Three antepygidial bristles all spinelike, two outer ones much shorter. 8*t* with dorsal spiculose area on inner side. Female with three antepygidial bristles. Stylet with one lateral bristle........ *Paraceras* Wagner.

Outer surface of fore femur with few lateral bristles. Male, bristles of second antennal segment not reaching to one-third of club. One antepygidial bristle as a rule, upper one minute, lower one minute or wanting. 8*t* without dorsal spiculose area on inner side. Female with two to three antepygidial bristles. Stylet with two to five lateral bristles .... 7.

7\. Male, 8*s* narrow, with apical bristles, but without membranous flap. Finger claviform. Female, three antepygidial bristles (sometimes two to five). Stylet with two to five lateral bristles. *Oropsylla* Wagner et Ioff.

Male, 8*s* small or rudimentary. Finger swordlike. Female, two antepygidial bristles. Stylet with dorsal lateral bristle smaller than ventral .... *Diamanus* Jordan.

8\. First pair of plantar bristles of fifth tarsal segment shifted ventrad and situated between second pair. Eye almost rudimentary or lacking. Hind tibia, in addition to usual spines, with an apical comb row of three or four short and equal spines. Male clasper without acetabular bristles .... *Amphipsylla* Wagner.

First pair of plantar bristles of fifth tarsal segment not shifted ventrad; if so, not situated between second pair. Eyes developed, often divided into two parts, upper light-colored, lower dark. Hind tibia without apical comb row. Male clasper with one or two acetabular bristles.. 9.

9\. Antepygidial bristles present in both sexes. 7*t* without median process. 8*t* dorsolaterally without elongate, horizontal sclerite bearing a condylus .... 10.

Antepygidial bristles none in male, three in female. 7*t* with median process reaching to middle of pygidium in male and shorter in female. 8*t* dorsolaterally with an elongate, horizontal sclerite bearing a condylus .... *Geusibia* Jordan.

10\. Eye peculiarly divided into an upper lightly pigmented and a lower deeply pigmented part which appears as a second eye. All three antepygidial bristles in male spinelike. Clasper with acetabular projection bearing a single acetabular bristle. *Ophthalmopsylla* Wagner et Ioff.

Eye normal. One or sometimes both of outer two of three antepygidial bristles in male minute or wanting. Clasper often without acetabular projection, but bearing one or two acetabular bristles .... 11.

11\. Occiput with two rows of bristles (excluding apical row). Frontal tubercle conical. Male, clasper with two acetabular bristles. 8*t* longitudinally divided into two lobes. Female, division between head and tail of spermatheca not distinct........ *Frontopsylla* Wagner et Ioff.

Occiput with one rudimentary row of bristles as a rule. Frontal tubercle small or wanting. Male, clasper with one, scarcely two, acetabular bristles. 8*t* not longitudinally divided into two lobes. Female, division between head and tail distinct. *Paradoxopsyllus* Miyajima et Koidsumi.

1. Genus CERATOPHYLLUS Curtis, 1832 (sensu lato)

Labial palpus reaching to apex of forecoxa in most cases, but in subgenus *Citellophilus* extending beyond apex of fore tro-

chanter. Ocular bristle situated lower than upper margin of eye. Bristles of second antennal segment in male never projecting beyond apex of club. One frontal row of none to seven bristles in female (except in subgenus *Pleochætis* in which one or two rows may be present). Inner surface of mid- and hind coxæ with longish thin bristles at most in apical half; if bristles are present on basal half, posterior portion of 8*t* of female widened to form a process at top and anal sternite longitudinally split into two lobes and much longer than anal tergite. Outer surface of fore femur with a number of small lateral bristles. Longest bristle of second hind tarsal segment often not reaching beyond apex of fourth. First pair of plantar bristles of fifth tarsal segment situated as laterally as are other pairs or only slightly moved ventrad. Male, one or both of the outer two of three antepygidial bristles minute or wanting. 8*s*, except in subgenus *Nosopsyllus*, well developed. Finger of various forms. Ejaculatory duct normal. Female, two or three antepygidial bristles. Stylet with one apical bristle, and one to three lateral bristles.

The old genus *Ceratophyllus* has for years been the most puzzling group of Siphonaptera. A few years ago it was broken up into a number of genera by Wagner (1927, 1934) and Jordan (1933). Recently Ioff (1936) studied the subfamily Ceratophyllinæ and, as a result, suppressed some of Jordan's and Wagner's genera as subgenera of *Ceratophyllus* (*sensu lato*).

Key to the subgenera of Ceratophyllus (sensu lato).

1. Male, 8*s* rudimentary. Two antepygidial bristles, upper bristle short but stout, lower rudimentary. Female, bursa copulatrix rolled up as a spiral .... *Nosopsyllus* Jordan (*sensu lato*) 2.
   Male, 8*s* developed. Usually one antepygidial bristle, outer two either rudimentary or of unstable stoutness. Female, bursa copulatrix not rolled up as a spiral .... 3.
2. Longest apical bristle of second hind tarsal segment extending beyond apex of fourth segment .... § *Gerbillophilus* Wagner.
   Longest apical bristle of second hind tarsal segment not extending beyond apex of fourth segment........ § *Nosopsyllus* Jordan (*sensu stricto*).
3. Inner surface of mid- and hind coxæ with longish thin bristles not only on apical half but also on basal half. Male, anal sternite projecting considerably beyond anal tergite. Bursa copulatrix sac-shaped........ 4.
   Inner surface of mid- and hind coxæ with longish thin bristles only on apical half .... 5.
4. Male, 8*t* with dorsal spiculose area on inner side. Posterior apex of finger with stout bristles or a pair of sharp spiniforms which are not close to each other. Female, two antepygidial bristles.
   Citellophilus Wagner.

Male, 8*t* without dorsal spiculose area on inner side. Posterior apex of finger with two short, blunt, dark spiniforms which are close to each other. Female, three antepygidial bristles............ *Callopsylla* Wagner.

5. Pronotal comb consisting of twenty-four spines or more, seldom twenty-three. Male, 8*t* with dorsal spiculose area on inner side.
Ceratophyllus Curtis (*sensu stricto*).

Pronotal comb consisting of less than twenty-four spines. Male, 8*t* without dorsal spiculose area on inner side.
Monopsyllus Kolenati (*sensu stricto*).

1. Subgenus CERATOPHYLLUS Curtis, 1832 (sensu stricto)

Frontal row developed, two to seven bristles in female. Eyes developed. Labial palpus not reaching to apex of fore coxa. Bristles of second antennal segment extending to middle or three-fourths of club in male and beyond apex of club in female. First occipital row consisting of none or one bristle, second occipital row consisting of two bristles. Pronotal comb with twenty-four or more spines. Inner surface of mid- and hind coxæ with longish thin bristles only on apical half. Longest bristle of second hind tarsal segment not reaching beyond apex of fourth segment. Male, one long antepygidial bristle, other two minute. 8*t* with spiculose area. 8*s* rodlike, with apical bristles (often spiniform) and membranous apical flap. 9*s* with apex of anterior arm widened posteriorly and with antemedian portion of posterior arm roundly dilated. Female, three antepygidial bristles (one long, other two much shorter). Stylet with one to three lateral bristles. Bursa copulatrix and spermatheca variable, in typical species portion of duct of spermatheca nearest bursa copulatrix more strongly sclerotized, being a conspicuous tube, head of spermatheca cylindrical, concave above, several times as long as broad.

Key to the species of the subgenus Ceratophyllus.

1. Female, apex of 7*s* strongly rounded. Male, anterior and posterior margins of finger almost parallel in upper half. Notch of anterior margin of finger at or near third from bottom. 8*s* with two or three apical bristles on each side.. *C. gallinæ* (Schrank).

Female, apex of 7*s* rounded in upper half, incurved in lower half. Male unknown .... *C. sinicus* Jordan.

CERATOPHYLLUS (CERATOPHYLLUS) GALLINÆ (Schrank, 1803). Text figs. 4 and 5.

Frontal row present. First occipital row represented by one bristle near base of antennal groove, second occipital row composed of a short and a long bristle above middle of antennal groove. Pronotal comb one-eighth shorter than pronotum and consisting of twenty-six to twenty-eight spines. Apical area of

metanotum one-third shorter than corresponding area of mesonotum and bearing on each side two short apical spines.

Male.—8*t* with six or seven bristles at and near margin and a few on lateral surface. 8*s* evenly curved, with two or three long apical bristles on each side, these bristles about one-fifth shorter than finger. Process of clasper short, triangular. Finger four times as long as broad, posterior margin slightly incurved below center, then feebly convex, apex rounded. Finger excluding basal region of almost even width; three long bristles on apical half of posterior margin, upper bristle thinner and shorter than others; in between upper bristle and the next a short thin spinelike bristle; finger measured from most ventral point to upper anterior angle with notch of anterior margin at one-third or two-fifths from bottom. End piece of paramere twice as long as width of finger.

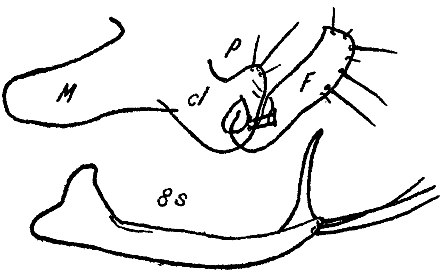


FIG. 4. *Ceratophyllus* (*Ceratophyllus*) *gallinæ*, male. (After Jordan and Rothschild.)

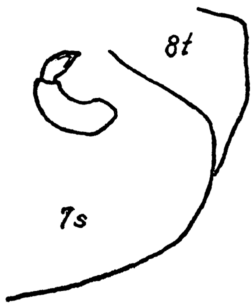


FIG. 5. *Ceratophyllus* (*Ceratophyllus*) *gallinæ*, female. (After Jordan and Rothschild.)

Female.—Apex of 7*s* strongly rounded, without sinus. 8*t* with three to five bristles below stigma, one or two long, on ventral area of 8*t* about a dozen bristles. Stylet about three times as long as broad. Head of spermatheca long and slender, almost three times as long as broad, and twice length of tail, which is two-thirds width of head.

2. CERATOPHYLLUS (CERATOPHYLLUS) SINICUS Jordan, 1932. Text fig. 6.

Female.—Anterior frontal row composed of four or five bristles. Pronotum with a comb of twenty-eight spines and a row of fourteen long bristles. On meso- and metanota a row of eleven to twelve bristles and in front of row about twenty-two small bristles. Mesonotum with eight false spines. Metepimeron with three rows of bristles (two or three, three, one). Apex of 7*s* slightly incurved in ventral half, upper half strongly rounded and projecting beyond ventral half. 8*t* with ten or

eleven bristles above stigma and three or four below stigma. Stylet less than twice as long as broad, and provided with three lateral bristles. Apex of bursa copulatrix sclerified. Sclerified portion of duct of spermatheca as long as bursa copulatrix and duct combined. Spermatheca with a curved cylindrical head which is about three times as long as tail; tail only little narrower than head.

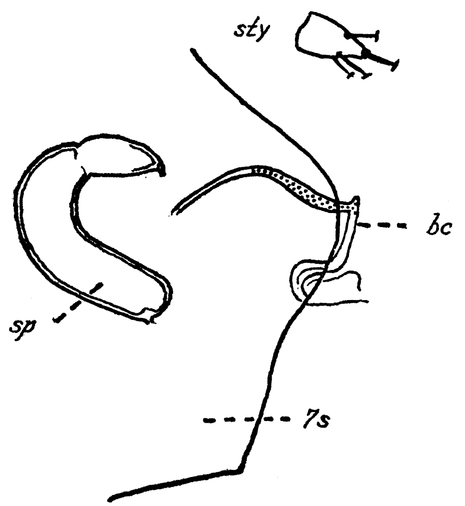


FIG. 6. *Ceratophyllus (Ceratophyllus) sinicus*, female. (After Jordan.)

2. Subgenus MONOPSYLLUS Kolenati, 1857

Frontal row present, one to five bristles in female. Eye not reduced. Labial palpus reaching about to apex of fore coxa. Bristles of second antennal segment reaching, or not reaching, to middle of club in male and to one-half to three-fourths in female. First occipital row of none to two bristles with one bristle as a rule, second row of two bristles. Pronotal comb of twenty-two or fewer spines. Inner surface of mid- and hind coxæ with longish thin bristles at most in apical half. None of bristles of first and second hind tarsal segments extending beyond following segment.

Male.—Three antepygidial bristles, one long, outer two of varying stoutness. 8*t* without dorsal spiculose area on inner side. 8*s* narrow, with or without membranous apical flap. Frontal margin of 9*t* forming with manubrium of clasper an acute, rounded-off angle.

Female.—Three antepygidial bristles. Stylet with two lateral bristles. Spermatheca of various forms.

3. CERATOPHYLLUS (MONOPSYLLUS) ANISUS Rothschild, 1908. Text figs. 7 and 8.

Frontal tubercle prominent. Occiput with one long bristle above middle of hind margin of antennal groove and a smaller one above long bristle. Pronotal comb composed of sixteen to twenty spines. Longest apical bristle of second hind tarsal segment somewhat shorter than third segment.

Male.—8*t* with seven or eight bristles above and two below. 8*s* very long and slender, little curved and ventrally near apex with two pairs of bristles. Process of clasper conical. Finger elongate, anterior apex pointed, posterior apex rounded, anterior margin distinctly excurved above acetabular bristles. Anterior arm of 9*s* strongly curved; central widened portion of posterior arm with numerous bristles.

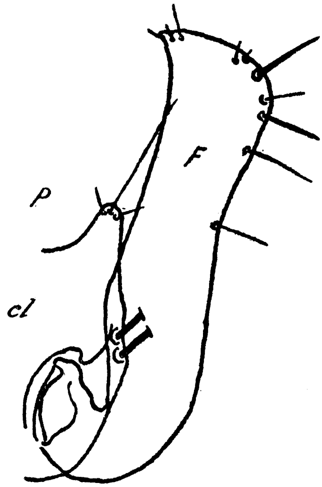


FIG. 7. *Ceratophyllus* (*Monopsyllus*) *anisus*, male. (After Jordan.)

Female.—Three antepygidial bristles rather short. Apex of 7*s* rounded in outline. 8*t* with several bristles below stigma, of which only one is very stout. Spermatheca resembling that of *Ceratophyllus* on birds, with its cylindrical head about three times as long as tail.

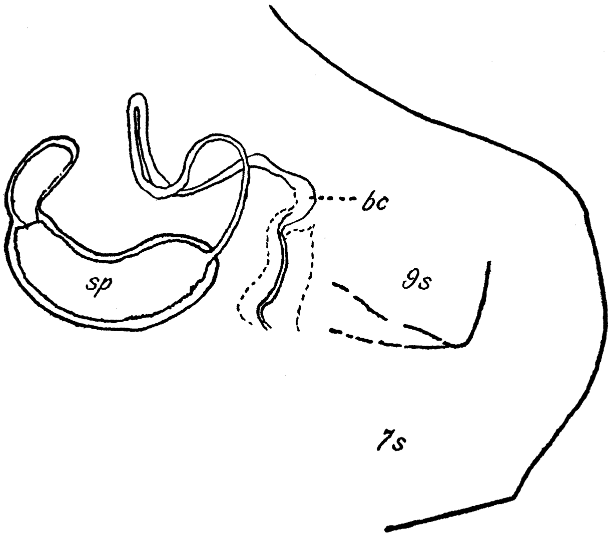


FIG. 8. *Ceratophyllus* (*Monoysyllus*) *anisus*, female. (After Jordan.)

3. Subgenus NOSOPSYLLUS Jordan, 1933 (sensu lato)

Frontal row absent or present (none to six bristles in female). Eyes not reduced. Labial palpus with apex reaching to or beyond apex of fore coxa. Bristles of second antennal segment not reaching to one-third of club in male, but reaching to middle

or beyond apex of club in female. First occipital row composed of none to two bristles, second row of one or two bristles. Pronotal comb composed of fewer than twenty-four spines. Inner surface of mid- and hind coxæ with longish thin bristles at most in apical half. Longest bristle of second hind tarsal segment reaching or not reaching beyond apex of fourth segment.

Male.—One long antepygidial bristle, upper bristle short and stout, lower rudimentary. 8*t* without dorsal spiculose area on inner side. 8*s* rudimentary or quite small, within 7*s*, without bristles. 9*s* with anterior arm triangularly dilated on frontal side below apex and with posterior arm sinuate at middle.

Female.—Three antepygidial bristles. Stylet with one single apical bristle and one lateral bristle. Spermatheca with nearly globular head and long cylindrical tail. Bursa copulatrix with long sclerotized duct, upper end membranous, rolled up in a spiral.

Key to the sections of the subgenus Nosopsyllus.

1. Labial palpus reaching to about apex of fore coxa. Frontal row composed of one to six bristles in female. Bristles of second antennal segment reaching to middle or beyond apex of club in female. Longest bristle of second hind tarsal segment not reaching beyond apex of fourth segment.................................... *Nosopsyllus* Jordan (*sensu stricto*).

   Labial palpus reaching to, or beyond, apex of fore coxa. Frontal row absent in female. Bristles of second antennal segment reaching beyond apex of club in female. Longest bristle of second hind tarsal segment reaching beyond apex of fourth segment............ *Gerbillophilus* Wagner.

4. CERATOPHYLLUS (NOSOPSYLLUS) FASCIATUS Bosc, 1801. Text figs. 9 and 10.

Pronotal comb composed of about eighteen spines. Longest bristle of second hind tarsal segment not reaching to apex of

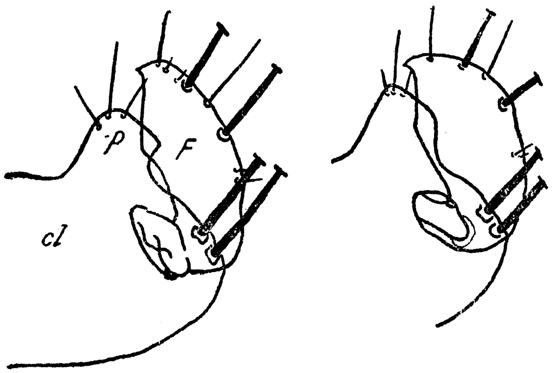


FIG. 9. *Ceratophyllus* (*Nosopsyllus*) *fasciatus*, male, variations of clasper, process, and finger. (After Jordan and Rothschild.)

third segment. Fifth tarsal segments all slightly shorter than third hind tarsal segments.

Male.—8*t* rounded posteriorly. 8*s* small and situated within 7*s*. Angle formed by dorsal portion of 9*s* and manubrium very obtuse. Process of clasper short, broad, truncate at apex. Posterior margin of finger in form of a semicircle; finger widest at notch of anterior margin and about twice as long as broad; apex hooked and directed frontad; upper half of posterior margin provided with two large bristles, upper bristle nearly always distinctly shorter than lower bristle; a thin bristle between stout bristles and another near apex; below middle of margin a third thin bristle accompanied by a smaller

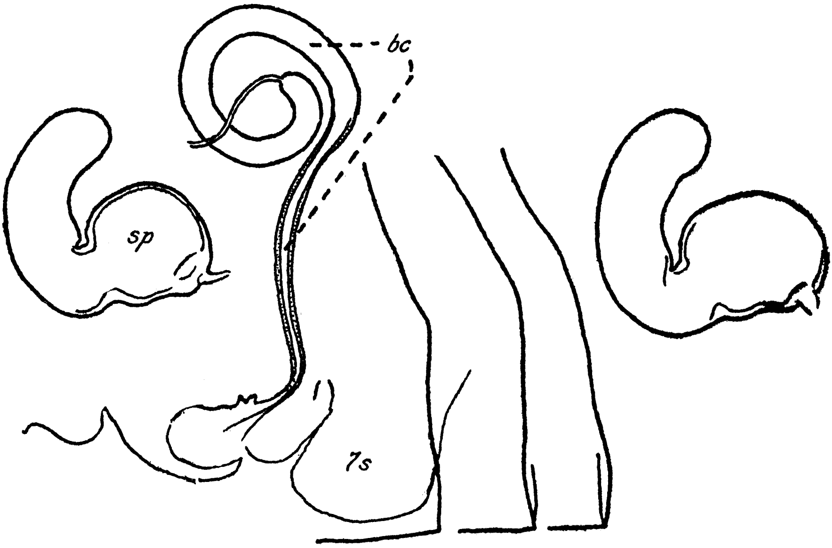


FIG. 10. *Ceratophyllus* (*Nosopsyllus*) *fasciatus*, female, variations of seventh sternite and spermatotheca. (After Jordan and Rothschild.)

one. Anterior arm of 9*s* with a ventral sinus at apex; proximal to deep ventral sinus of posterior arm usually one or two bristles larger than others.

Female.—Apex of 7*s* more or less irregularly rounded or slanting, sometimes slightly incurved, never distinctly sinuate. Stylet almost three times as long as broad, upper lateral bristle wanting. Spermatheca with nearly globular head; tail of even width and much longer than head.

5. CERATOPHYLLUS (GERBILLOPHILUS) LÆVICEPS Wagner, 1929. Text fig. 11.

Frontal tubercle prominent. Occiput with one stout bristle behind posterior antennal margin. Pronotal comb composed of twenty to twenty-two spines. Mesonotum with two rows and

metanotum with three rows of bristles. Metepimeron with three rows of bristles (one or two, three or four, one or two). Abdominal sternites of typical female *læviceps* with numerous bristles. The present subspecies differs from the typical form in the absence of a group of additional lateral bristles on basal sternites and by a smaller number of bristles on abdominal sternites.

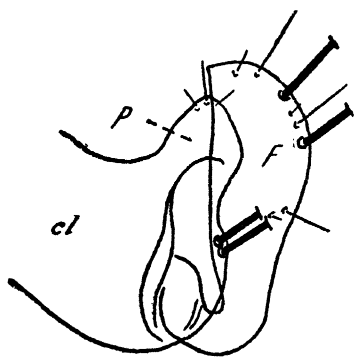


FIG. 11. *Ceratophyllus* (*Gerbillophilus*) *læviceps læviceps*, male. (After Wagner.)

Male.—8*t* provided with six or seven marginal bristles along dorsal margin (instead of thirteen in the typical subspecies, *læviceps læviceps* Wagner, 1909). Process of clasper thumblike, provided with three hairs at apex. Manubrium tapering toward apex which is, however, not pointed, but more or less rounded. Finger widest at distal third and less obliquely truncate at apex (obliquely truncate in *læviceps læviceps*); posterior apical margin with two bristles, which are less apart than in the typical subspecies. Proximal apex of 9*s* enlarged into a club which is, however, drawn out into a pointed apex; distal apex less markedly tapering or narrowed and provided with two spiniforms.

Female.—7*s* with a more or less truncate apex. 8*t* deeply sinuate at posterior apex and provided with numerous bristles near apical portion. Spermatheca with short oval head and a tail of even width.

4. Subgenus CALLOPSYLLA Wagner, 1934

Frontal row either absent or unstable (as many as six bristles may be present). Eyes developed or nearly rudimentary. Labial palpus extending almost always to apex of fore coxa. Bristles of second antennal segment reaching at most to middle of club in male, but beyond apex of club in female. First occipital row consisting of none to two bristles, second occipital row of one to five bristles. Pronotal comb composed, as a rule, of less than twenty-four spines, in one group composed of twenty-four to twenty-six spines. Inner surfaces of mid- and hind coxæ with longish thin bristles from base (at least one) to apex. Longest apical bristles of second hind tarsal segment not reaching beyond apex of fourth segment.

Male.—One developed antepygidial bristle. 8*t* without spiculose area. 8*s* with apical membranous lobe or flap. Finger triangular or quadrangular, with two short blunt spiniforms which are close to each other and below which is a thickened bristle. Anal sternite projecting far beyond anal tergite.

Female.—Three antepygidial bristles. Head of spermatheca barrel-shaped. Ductus obturatorius present. Bursa copulatrix with a saclike widening, usually with sclerotized incrassation. Three species known from China.

Key to the species of Callopsylla.

1. Frontal row reduced (none to three bristles). Two occipital rows reduced (none or one, one). Pronotal comb composed of less than twenty-four spines. Male, process of clasper long (more than twice as long as wide at base), dilated at apex. Finger with more or less rounded posterior apex. Female, apex of 7*s* truncate and slightly incurved twice .... 2.
   Frontal row developed (five or six bristles). Two occipital rows developed (one or two, four or five). Pronotal comb composed of twenty-four to twenty-six spines. Male, process of clasper short (as long as wide at base), not distinctly dilated at apex. Finger with sharp posterior apex. Female, apex of 7*s* with a sinus, upper and lower lobes equally rounded off .... *C.* (*C.*) *kaznakovi* Wagner.
2. Male, anterior and posterior margins of finger strongly arched, distal margin evenly rounded. Female unknown.... *C.* (*C.*) *kozlovi* Wagner.
   Male, anterior and posterior margins of finger not strongly arched, anterior margin with an excurving and distal margin more or less straight. Female, apex of 7*s* truncate and slightly incurved twice.
   C. (*C.*) *dolabris* Jordan et Rothschild.

6. CERATOPHYLLUS (CALLOPSYLLA) KOZLOVI Wagner, 1929. Text fig. 12.

Male.—Frontal tubercle prominent. Frontal row consisting of two or three bristles. First occipital row with only one very feeble bristle. Pronotal comb composed of eighteen or nineteen spines. 8*s* on apex with three pairs of ventral bristles and a large, wide, membranous, apical, lateral lobe. Finger dilated at apex, sharply narrowed at basal portion so that it looks like a mushroom; hind dorsal corner with a pair of curved blunt spiniforms.

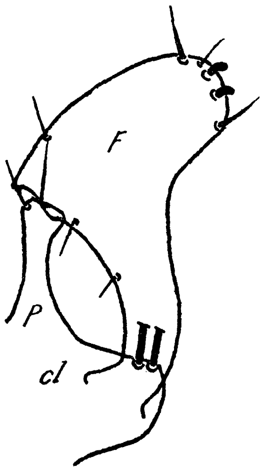


FIG. 12. *Ceratophyllus* (*Callopsylla*) *kozlovi*, male. (After Wagner.)

7. CERATOPHYLLUS (CALLOPSYLLA) DOLABRIS Jordan et Rothschild, 1911. Text figs. 13 and 14.

Frontal tubercle prominent. Bristles of second antennal segment of female long, at least five reaching beyond apex of club. Occiput with one long bristle above antennal groove. Pronotal comb composed of seventeen or eighteen spines, usually an additional small spine on each side. Meso- and metanota with two rows of bristles (six, twelve on two sides together). Metepimeron with four to six bristles (one or two, two or three, one). Longest apical bristle of second hind tarsal segment reaching beyond apex of third segment.

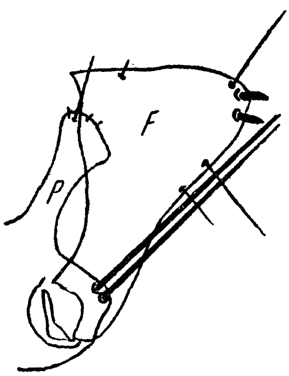


FIG. 13. *Ceratophyllus* (*Callopsylla*) *dolabris*, male. (After Jordan and Rothschild.)

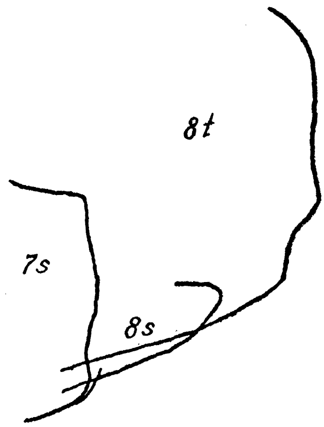


FIG. 14. *Ceratophyllus* (*Callopsylla*) *dolabris*, female. (After Jordan and Rothschild.)

Male.—8*t* with three bristles below stigma, a row of six to eight bristles at upper edge of apical lobe, with one or two bristles close to row and an irregular row of five or six bristles near ventral edge. 8*s* with three apical bristles on each side. Process of clasper dilated at apex. Finger triangular, upper apical margin on the whole more or less truncate though slightly wavy, anterior apical corner acute, on posterior apical corner two pointed spiniforms, above which is a long bristle and a little farther below, two long bristles. 9*s* with central ventral lobe of posterior arm bearing a number of rather strong, short bristles at apex; thin, pale, distal lobe paramecium-shaped.

Female.—7*s* truncate at apex, slightly incurved twice. 8*t* with five or six bristles below stigma in two rows, upper angle of apical lobe strongly rounded.

8. CERATOPHYLLUS (CALLOPSYLLA) KAZNAKOVI Wagner, 1929. Text fig. 15.

Frontal tubercle marked. Frontal row composed of five or six bristles. First occipital row consisting of one or two, second of three to five bristles. Pronotal comb consisting of twenty-four spines. Longest apical bristle of first hind tarsal segment longer than second segment.

Male.—8*s* with two pairs of long subapical bristles and a nearly quadriform membranous lateral lobe. Process of clasper short and broad. Finger ax-shaped, fore and hind margins incurved, on posterior apex a pair of closely set, short spiniforms, immediately below these a long acute spine. Anterior arm of 9*s* nearly straight.

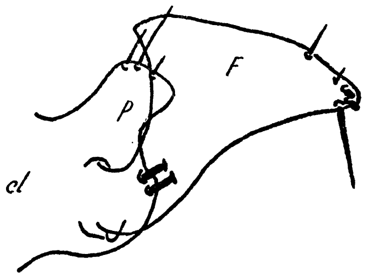


FIG. 15. *Ceratophyllus* (*Callopsylla*) *kaznakovi*, male. (After Ioff.)

Female.—Central antepygidial bristle about twice as long as others. Apex of 7*s* distinctly sinuate, upper and lower lobes equally rounded off. 8*t* with considerably stout marginal bristles and about ten lateral bristles.

5. Subgenus CITELLOPHILUS Wagner, 1934

Frontal row absent or only uppermost bristle present. Eyes developed. Labial palpus with its apex reaching or beyond apex of fore trochanter. Bristles of second antennal segment reaching at most to middle of club in male, but reaching beyond club in female. First occipital row lacking, second represented by only one bristle. Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Apical bristles of second hind tarsal segment not reaching beyond apex of fourth segment.

Male.—One developed antepygidial bristle on each side. 8*t* with spiculose area. 8*s* somewhat shortened, with apical lobe. Finger triangular, provided with stout bristles or a pair of spiniforms which are wide apart. Anterior arm of 9*s* not curved but straight. Anal sternite longitudinally divided into two halves or lobes, projecting far beyond anal tergite.

Female.—Two antepygidial bristles as a rule. Spermatheca with egg-shaped head and large, irregular, spindle-shaped tail. Only one species of this subgenus occurs in China.

Key to the subspecies of Ceratophyllus (Citellophilus) tesquorum.

1. Female, apex of 7s slanting or undulating. Ten bristles of second antennal segment reaching to apex of club or beyond. Spermatheca with head as long as tail.
   C. (C.) tesquorum famulus Jordan et Rothschild.

   Female, apex of 7s more or less truncate and with central excurving. About five bristles of second antennal segment reaching to the apex of club or beyond. Spermatheca with head slightly shorter than tail..... 2.
2. Male, apex of finger more slanting and rounded.
   C. (C.) sungaris Jordan.

   Male, apex of finger neither slanting nor rounded. Female, apex of 7s truncate and slightly excurved at middle.
   C. (C.) mongolicus Jordan et Rothschild.

9a. CERATOPHYLLUS (CITELLOPHILUS) TESQUORUM MONGOLICUS Jordan et Rothschild, 1911. Text fig. 16.

Frontal tubercle small, pronotal comb composed of twenty spines. Labial palpus reaching a little beyond trochanter and therefore longer than that of typical *tesquorum* Wagner. First midtarsal segment distinctly shorter than second. Meso- and metanota with two rows of bristles. Metepimeron with six bristles (two, three, one).

Male.—8s with some weak hairs instead of five short, thick bristles. Process of clasper much less dilated at apex than in *tesquorum tesquorum*. Manubrium of even width, rounded at apex. Finger triangular, widest at apex, with two widely separated spiniforms on upper half of posterior margin. Finger as a whole much less widened at apex, apical margin one-fourth shorter than in typical *tesquorum*, proportions of length and width of finger 7 : 4 in *mongolicus* and 7 : 5 in *tesquorum*.

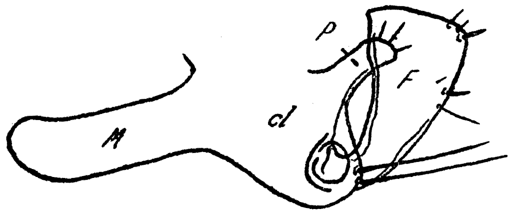


FIG. 16. *Ceratophyllus (Citellophilus) tesquorum mongolicus*, male. (After Jordan and Rothschild.)

Female.—7s on each side with a row of twelve or thirteen bristles and about six small bristles before this row; apex like in typical *tesquorum*, truncate, margin very slightly excurved centrally. 8t with a cluster of five or six bristles below stigma and about fifteen bristles at and near ventral and apical margins, apex widely sinuate below rounded upper lobe.

9b. CERATOPHYLLUS (CITELLOPHILUS) TESQUORUM SUNGARIS Jordan, 1929. Text fig. 17.

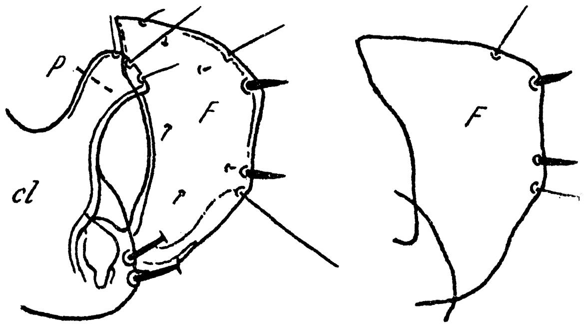


FIG. 17. *Ceratophyllus* (*Citellophilus*) *tesquorum sungaris*, male, variations. (After Jordan.)

Male.—Allied to *C.* (*C.*) *tesquorum mongolicus.* Differs in that the finger is more rounded posteriorly, with the apical margin more slanting than in other known subspecies.

Female unknown.

9c. CERATOPHYLLUS (CITELLOPHILUS) TESQUORUM FAMULUS Jordan et Rothschild, 1911. Text fig. 18.

Female.—Ten bristles of second antennal segment reaching to, or beyond, apex of club. Two apical antennal bristles of second hind tarsal segment extending to apex of third segment or beyond. Apical margin of 7*s* slanting and slightly undulating. Seventh segment with ten long bristles in a row and about thirty additional bristles, on the two sides together. 8*t* with two rows of bristles beneath stigma and about sixteen bristles on lower half, apex of 8*t* rounded-truncate with a dorsal sinus, above which is a distinctly produced upper angle. 9*s* with several small bristles. Stylet in shape resembling champagne bottle, twice as long as broad at base. Head of spermatheca as long as tail.

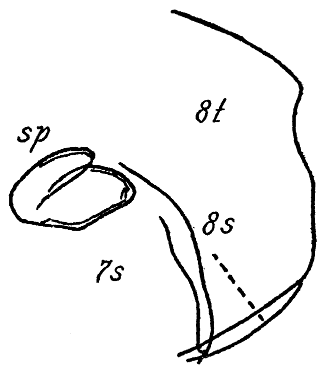


FIG. 18. *Ceratophyllus* (*Citellophilus*) *tesquorum famulus*, female. (After Jordan and Rothschild.)

SPECIES INCERTÆ SEDIS

Under the genus *Ceratophyllus* there are two other species the actual position of which is not yet clear, owing to the insufficiency of material at present, as remarked by Wagner (1934). Moreover, their original descriptions, based on a single female, do not permit of exact determination. For the sake of convenience these species may for the present be retained under the name *Ceratophyllus*, although it is improbable that they will remain there.

10. CERATOPHYLLUS (?) PHÆOPSIS Jordan et Rothschild 1911. Text fig. 19.

Female.—Front very slanting; frontal tubercle about halfway between oral corner and central sensory organ (pale spot). Eyes feebly pigmented except anterior and posterior edges, appearing deeply excised at a certain focus. Labial palpus reaching to apex of forecoxa. Three long bristles in front of eye, uppermost bristle placed near antennal groove. Occiput bearing one bristle above antennal groove and subapical row of five bristles. Bristles on second antennal segment minute. Pronotal comb composed of eighteen spines. Meso- and metanota bearing each two rows of bristles. Metepimeron with eight bristles (four, three, one). Second hind tarsal segment bearing an apical bristle reaching beyond apex of fourth segment and another bristle beyond apex of third segment. Fifth hind tarsal segment with five pairs of lateral plantar bristles. Abdominal tergites and sternites each bearing two rows of bristles. Three antepygidial bristles, lower bristle but little shorter than middle bristle. Apex of 7*s* with a deep sinus strengthened proximally by a curved bandlike incrassation. 8*t* with three bristles below stigma, apical margin rounded. Stylet short, bottle-shaped, twice as long as broad at base. Spermatheca distorted, head appearing round and much shorter than tail.

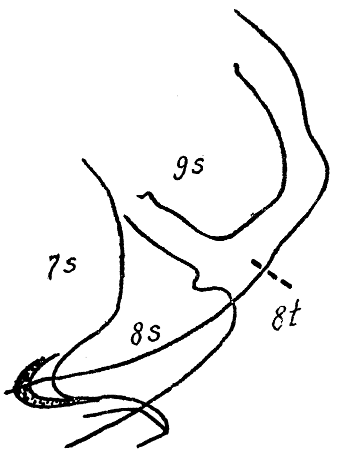


FIG. 19. *Ceratophyllus* (?) *phæopsis*, female. (After Jordan and Rothschild.)

CERATOPHYLLUS (?) SPARSILIS Jordan et Rothschild, 1922. Text fig. 20.

Female.—Front gradually and strongly slanting, with a row of three long bristles in front of eye. Labial palpus reaching to middle of fore trochanter. Five bristles of second antennal segment reaching far beyond club. Occiput with one long bristle above middle of antennal groove and a subapical row of five or six bristles. Pronotal comb consisting of twenty spines. Meso- and metanota with two rows of bristles. Six bristles on metepimeron (two, three, one). Fore femur with two or three dorsolateral bristles. Inner surface of mid- and hind coxæ with slender bristles extending to base. Longest bristle of second hind tarsal segment reaching to apex of third segment. Apex of 7*s* gradually rounded. 8*t* with eight to ten bristles above stigma and six below stigma, of which three are long. Stylet bottle-shaped, with one apical bristle and one ventrolateral bristle. Spermatheca with elongated head which is twice as long as broad. Bursa copulatrix sclerotized.

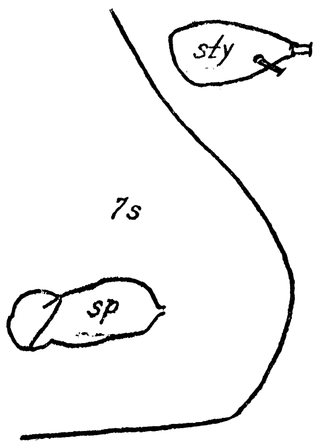


FIG. 20. *Ceratophyllus* (?) *sparsilis*, female. (After Jordan and Rothschild.)

2. Genus DIAMANUS Jordan, 1933

Labial palpus reaching beyond apex of fore trochanter. Ocular bristle situated lower than upper margin of eye. Bristles of second antennal segment in male short. Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Outer surface of fore femur with several small lateral bristles. Longest bristle of second hind tarsal segment reaching beyond apex of fourth segment. First pair of plantar bristles situated laterally as are other pairs.

Male.—One developed antepygidial bristle, the other two rudimentary. 8*s* quite small. Finger swordlike. Ejaculatory duct normal.

Female.—Two antepygidial bristles. Stylet with one apical bristle and with dorsal lateral bristle much smaller than ventral one. Spermatheca with globular head and slender tail.

Key to the species of Diamanus.

1. Inner surface of mesonotum near apex with eight to twelve bristlelike spines. Male, finger more or less straight. Manubrium slightly dilated at apex. Frontal margin of proximal portion of anterior arm of 9*s* strongly curved. Female, 8*t* sinuate at apex. Tail of spermatheca slightly, if not, dilated at apical third.
D. mandarinus (Jordan et Rothschild).

Inner surface of mesonotum without bristlelike spines near apex. Male, finger strongly curved. Manubrium distinctly dilated at apex. Frontal margin of proximal portion of anterior arm of 9*s* more or less straight. Female, 8*t* rounded at apex. Tail of spermatheca strongly dilated at apical third.. *D. montanus* (Baker).

12. DIAMANUS MANDARINUS (Jordan et Rothschild), 1911. Text figs. 21 and 22.

Frontal tubercle situated at one-third or one-fourth distance from oral corner to antennal groove. Before eye two long

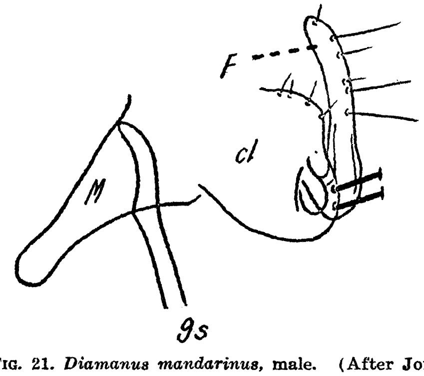


FIG. 21. *Diamanus mandarinus*, male. (After Jordan and Rothschild.)

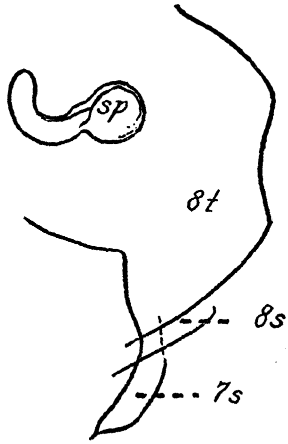


FIG. 22. *Diamanus mandarinus*, female. (After Jordan and Rothschild.)

bristles, ocular bristle accompanied by a smaller bristle. Two more bristles located more frontad in male, one near anterior margin of antennal groove and another behind maxillary palpus. Occiput with one bristle above antennal groove. Pronotal comb composed of eighteen to twenty-three spines. Inner surface of mesonotum near apex with nine to twelve bristlelike spines. Five bristles on metepimeron (two, two, one).

Male.—8*t* at dorsal margin beyond stigma with a row of four bristles, one below stigma, two on side, and two near ventral margin. 8*s* small, distally suddenly narrowed to a point. Clasper broad, upper angle rounded. Distal half of manubrium of

even width, slightly dilated at apex. Movable finger peculiarly slender, almost of same width throughout and with tip rounded off. Anterior arm of 9*s* very long and narrow; posterior arm divided by a deep ventral sinus, longer proximal portion at ventral margin with five or six bristles.

Female.—Apex of 7*s* evenly excurved below small upper apical angle. 8*t* above stigma, with eight to ten small bristles, two or three long bristles below stigma, and twelve long and ten to twelve shorter bristles on lower half; apex shallowly sinuate. Head of spermatheca globular, tail slender, about twice as long as head.

13. DIAMANUS MONTANUS MONTANUS (Baker), 1895. Text figs. 23 and 24.

Closely allied to preceding species. Pronotal comb composed of eighteen spines. Inner surface of mesonotum without bristle-like spines near apex.

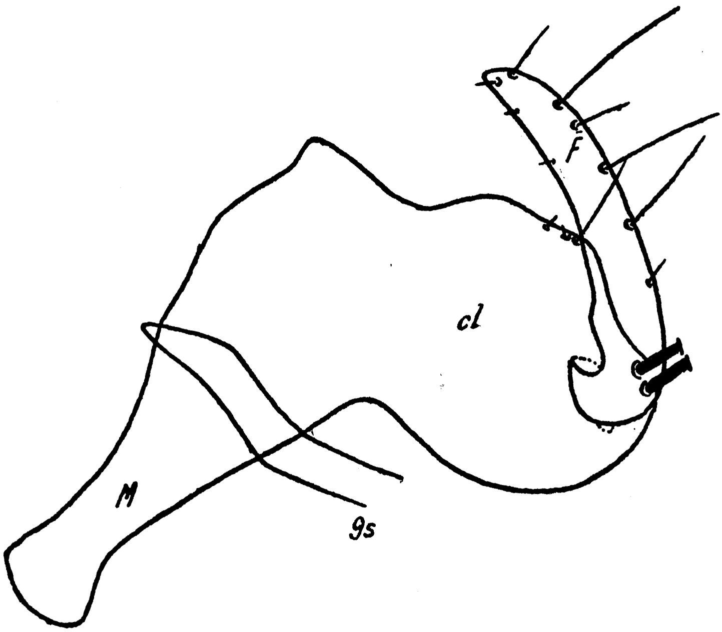


FIG. 23. *Diamanus montanus montanus*, male. (Author's drawing.)

Male.—Differing from preceding species in that the manubrium is strongly dilated at apex, the movable finger tapers gradually towards apex and is more or less curved, the proximal portion of the anterior arm of 9*s* is different in shape and curvature.

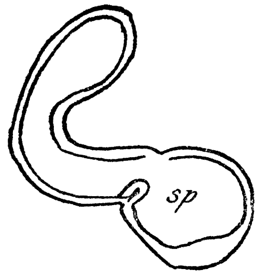


FIG. 24. *Diamanus montanus montanus*, female. (Author's drawing.)

Female.—Apex of 7*s* broadly rounded and with a ventral sinus. 8*t* rounded at apex. Tail of spermatheca strongly dilated at apical third.

3. Genus OROPSYLLA Wagner et Ioff, 1926

Eyes well developed. Frontal tubercle sharp, more or less sunken into front. Labial palpus reaching beyond apex of fore trochanter (1 to 1.5 joints beyond trochanter). Ocular bristle situated lower than upper margin of eye. Bristles of second antennal segment not reaching to middle of club in male, beyond apex in female. Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Outer surface of fore femur with several small lateral bristles. Longest apical bristle of second hind tarsal segment sometimes reaching beyond apex of fourth segment. First pair of plantar bristles situated laterally as are other pairs.

Male.—One long and one minute antepygidial bristle. 8*s* slender, without membranous apical lobe. Movable finger claviform. Process of clasper broad. Ejaculatory duct normal.

Female.—Three (two to five) antepygidial bristles. Stylet with one apical bristle and two to five lateral bristles. Head of spermatheca longer than broad, ovate or pyriform; tail short, usually not longer than head.

Key to the species of Oropsylla.

1. Frontal tubercle prominent. Labial palpus longer, apex of fourth joint at least on a level with base of fore trochanter. Pronotum (from basal margin to base of pronotal comb) longer than spines of pronotal comb. Male, posterior margin of movable finger semicircular in outline. Female, head of spermatheca smaller.... *O. silantiewi* (Wagner).

   Frontal tubercle barely traceable. Labial palpus shorter. Pronotum shorter than spines of pronotal comb. Male unknown. Female, head of spermatheca larger.. *O. elana* Jordan.

2. Female, no apical bristles on second hind tarsal segment extending beyond apex of third segment. Apical margin of 8*t* more or less truncate, slightly incurved twice............ *O. silantiewi silantiewi* (Wagner).

   Female, two apical bristles of second hind tarsal segment extending beyond apex of third segment. Apical margin of 8*t* also truncate, slightly incurved once.... *O. silantiewi crassus* (Jordan et Rothschild).

14a. OROPSYLLA SILANTIEWI SILANTIEWI (Wagner, 1898). Text figs. 25 and 26.

Frontal tubercle marked. Front of male obliquely vertical. Labial palpus reaching to a little beyond middle of fore femur.

Antennal groove widely open behind. Central part of eye not pigmented. A stout median bristle above middle of hind margin

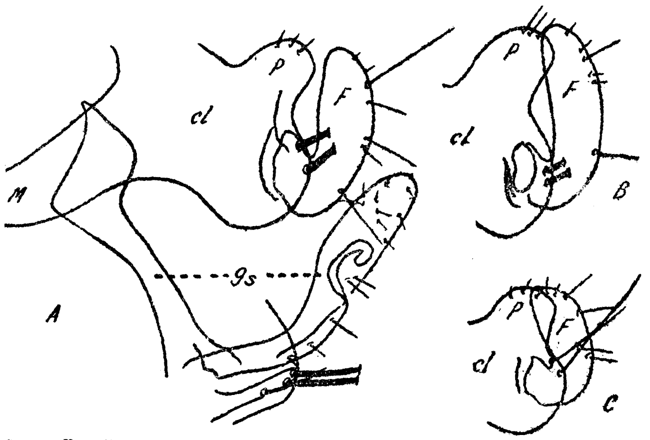


FIG. 25. *Oropsylla silantiewi silantiewi*, male, variations. (*A* and *B*, author's drawings; *C*, after Wagner.)

of antennal groove. Head feebly bristled, thorax and abdomen heavily bristled. Pronotal comb consisting of eighteen spines. None of apical bristles of hind tarsal segments exceeding apex of following segment. Oftentimes abdominal bristles in female not lying in rows and ventral side of abdomen presenting a hairy appearance.

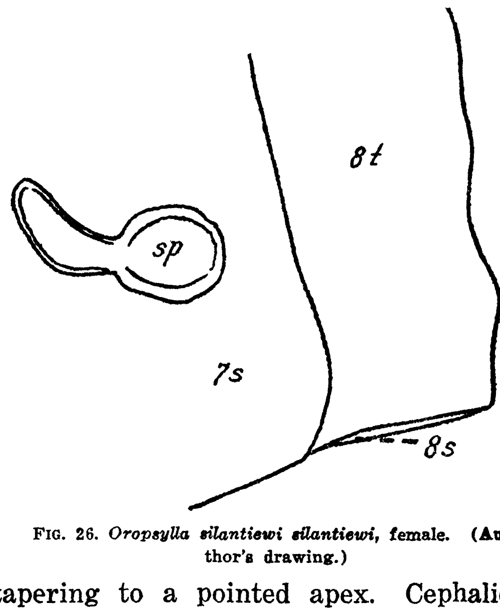


FIG. 26. *Oropsylla silantiewi silantiewi*, female. (Author's drawing.)

Male.—Clasper broad and short, process very much rounded. Movable finger shaped like a part of circle along its posterior margin, gradually rounded off at apex. Manubrium tapering to a pointed apex. Cephalic portion of anterior arm of 9*s* rectangular with the exception of an extra proximal process.

Female.—Apex of 7*s* truncate. Apical margin of 8*t* more or less truncate, being slightly incurved twice. Head of spermatheca shorter than tail, a little less than twice as broad as tail.

14b. OROPSYLLA SILANTIEWI CRASSUS (Jordan et Rothschild), 1911. Text fig. 27.

Female.—Similar to *O. silantiewi silantiewi.* Labial palpus shorter than that of *silantiewi,* apex of fourth joint on a level with base of fore trochanter. Pronotal comb of twenty to twenty-three spines. Two apical bristles of second hind tarsal segment reaching beyond apex of third segment. Mesonotum with numerous bristlelike spines on inner surface. Abdominal tergites bearing three rows of bristles, anterior row more or less irregular, second row reaching down to stigma, last row with two or three bristles below stigma. Apex of 8*t* obliquely truncate and slightly incurved. 8*t* bearing two long bristles below stigma, numerous bristles on lower half and three or more strong short bristles on inner surface. Stylet with three lateral bristles, two dorsal and one ventral. Spermatheca with a rounded head which is shorter than tail.

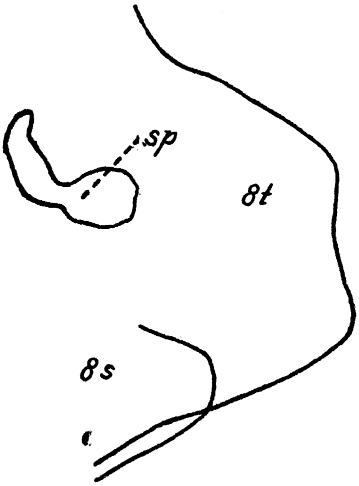


FIG. 27. *Oropsylla silantiewi crassus,* female. (After Jordan and Rothschild.)

15. OROPSYLLA ELANA Jordan, 1929. Text fig. 28.

Female.—Allied to *O. silantiewi crassus.* Frontal tubercle barely traceable. Labial palpus shorter than that of *crassus.* Apex of genal process evenly rounded, dorsally not more projecting than ventrally, a little shorter than in *crassus.* Pronotum shorter than spines of comb; comb composed of twenty-three to twenty-six spines. 7*s* more or less truncate at apex, upper angle distinct, sometimes a little more rounded than in figure, apex slightly variable, sometimes a little convex below middle, sometimes nearly straight or very slightly incurved. 8*t* bearing two to six bristles below stigma and many others on widened portion.

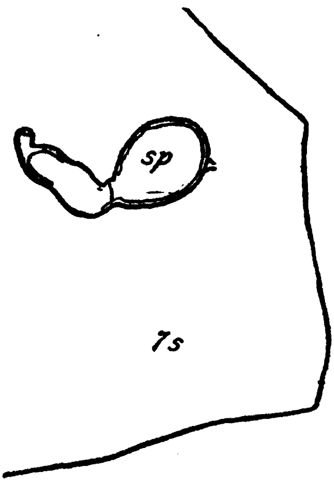


FIG. 28. *Oropsylla elana,* female. (After Jordan.)

Head of spermatheca larger than in *O. silantiewi crassus*, somewhat variable in shape.

4. Genus AMPHALIUS Jordan, 1933

Eyes well developed. Frontal tubercle sharp, more or less sunken into front. Labial palpus reaching about apex of fore trochanter. Ocular bristle situated lower than upper margin of eye. Bristles of second antennal segment reaching to three-fourths length of club in male and beyond apex in female. Pronotal comb consisting of more than twenty-four spines. Inner surface of mid- and hind coxæ with longish thin bristles from base to apex. Outer surface of fore femur with several small lateral bristles. Longest apical bristle of second hind tarsal segment not reaching beyond apex of fourth segment. First pair of plantar bristles somewhat shifted inward. 7*t* slightly projecting medianly in between two sets of antepygidial bristles.

Male.—One long antepygidial bristle. 8*t* very large, provided with dorsal spiculose area on inner side. 8*s* narrow, fringed on upper side with a large membranous fringed apical flap. Clasper with slender process. Movable finger with a long ventral process dilated at apex. Ejaculatory duct deeply coiled twice, apex directed frontad.

Female.—Three antepygidial bristles. Anal sternite with cylindrical stylet, the apex of which is rounded off and bears numerous bristles. Anal sternite angulate beneath, with bristles in apical half only. Spermatheca long, without distinct division between head and tail. Bursa copulatrix very long and broad.

Key to the species of Amphalius.

1. Male, process of clasper distinctly dilated at apex. Finger slender, subapical long bristle of ordinary type. Female, upper lobe of 7*s* broad. *A. clarus* (Jordan et Rothschild).
   Male, process of clasper very slightly dilated at apex. Finger broader, subapical bristle of a peculiar type, flattened like a blade. Female, upper lobe of 7*s* narrow................ *A. runatus* (Jordan et Rothschild).

16. AMPHALIUS RUNATUS (Jordan et Rothschild, 1923). Text fig. 29.

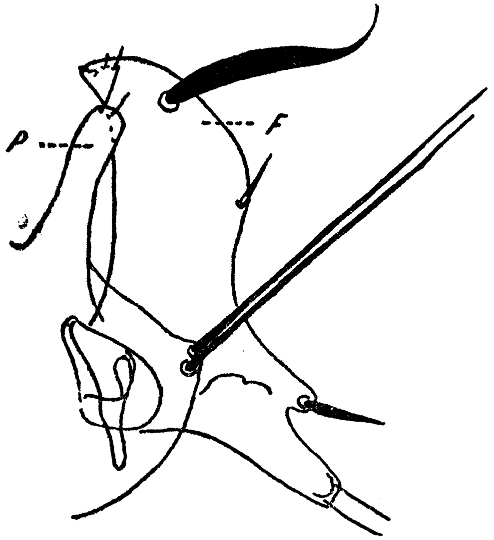


FIG. 29. *Amphalius runatus*, male. (After Jordan and Rothschild.)

Closely allied to *A. clarus.*

Male.—Process of clasper much slender, apex only slightly dilated. Finger much wider, subapical bristle broadened, flattened, bladelike, terminating in a long thin point. This single character is sufficient to distinguish this species from other members of the genus.

Female.—Almost identical with *A. clarus.* Two lobes of 7*s* varying to some extent, upper lobe narrower. Spermatheca V-shaped. Bursa copulatrix long, slightly broader than head.

17. AMPHALIUS CLARUS (Jordan et Rothschild, 1922). Text figs. 30 and 31.

Front with two rows of bristles (six, three). A long bristle accompanied by a small upper bristle above middle of posterior margin of antennal groove. Pronotal comb consisting of twenty-nine or thirty spines. Meso- and metanota with two rows of bristles and a few additional dorsal bristles. Three antepygidial bristles in female and a long bristle on a slightly projecting cone in male. First midtarsal segment with numerous long and slender bristles, longest bristle reaching to apex of third segment, three apical bristles of second hind tarsal segment reaching to base of fourth segment. First pair of plantar bristles of fifth segment of all tarsi distinctly shifted on to under surface.

Male.—8*t* bearing more than thirty bristles. 8*s* bearing distally a membranous fringed flap, the surface of which is clothed with numerous filaments. Manubrium of clasper of even width from near base to apex, which is rounded. Process of clasper long, apically rounded-dilated. Movable finger gradually narrowing upwards with apex bent frontad, widening out ventrally into a conical process armed with a short, stout, pointed, apical spine; this process again bearing a long appendage ex-

tending in an oblique anteroposterior direction, widened at apex. Anterior arm of 9*s* slender, apex acuminate, pointed upwards; posterior arm narrow, terminated by a ventral sinus. Flap beginning at this sinus very broad, bearing an obtuse, curved gourdlike bristle at anterior margin close to base.

Female.—Apex of 7*s* bisinuate, two sinuses separated by a short triangular lobe, lobe above upper sinus large and obtuse. 8*t* with ten or eleven bristles above stigma and six long bristles below it; ventral portion of 8*t* widened out, bearing about forty bristles. A process (10*t*) present, projecting between two stylets, bearing long bristles at apex. Stylet twice as long as wide, with more than a dozen apical bristles. Bursa copulatrix long and broad, about twice as broad as spermatheca. Spermatheca U-shaped, without distinct division between head and tail.

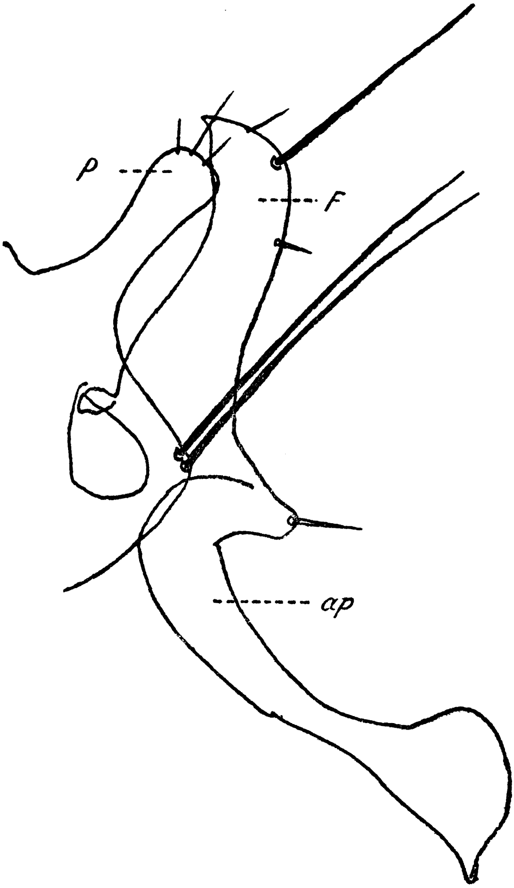


FIG. 30. *Amphalius clarus*, male. (After Jordan and Rothschild.)

5. Genus PARACERAS Wagner, 1916

Labial palpus reaching to or considerably beyond apex of fore trochanter (often with one joint beyond apex of trochanter). Frontal row represented by upper bristle. Ocular bristle situated lower than upper margin of eye. Bristles of second antennal segment reaching beyond apex of club in male and to middle in female. Pronotal comb present. Longest apical

bristle of second hind tarsal segment sometimes reaching beyond apex of fourth segment in male. First pair of plantar bristles situated laterally, like other parts. Outer surface of fore femur usually without small lateral bristles. Inner surface of mid- and hind coxæ with a few longish thin bristles which may be situated on basal half.

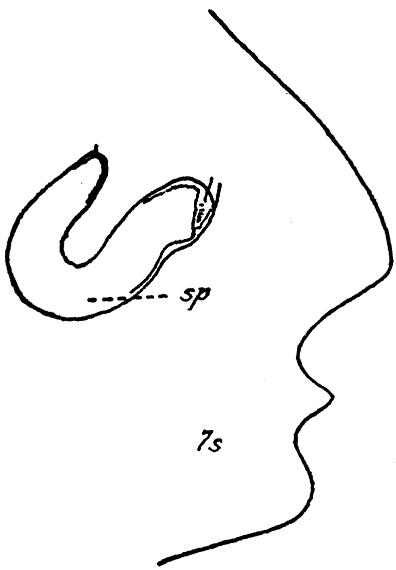


FIG. 31. *Amphalius clarus*, female. (After Jordan and Rothschild.)

Male.—Three spinelike antepygidial bristles, outer bristles much shorter. 8*t* strongly produced upwards into a lobe behind stigma, with dorsal spiculose area on inner side. 8*s* with complicated membranous apical flap bearing long fringes on ventral side. Dorsoposterior angle of finger produced into a lobe. Anal sternite not split, much longer than tergite.

Female.—Three antepygidial bristles. Stylet with one lateral bristle besides apical bristle. Head of spermatheca only slightly broader than tail. Apex of tail not sclerotized.

Key to the species of Paraceras.

1. Female, eye ball-shaped. Apex of 7*s* slanting or undulating. Male, process of clasper about one-third shorter than anterior margin of finger. Apex of finger more or less truncate. Distal apex of 9*s* narrowing almost to a point .... *P. crispus* (Jordan et Rothschild).
   Female eye-shaped. Apex of 7*s* with a distinct ventral triangular lobe. Male unknown .... *P. sinensis* (Liu).

18. PARACERAS CRISPUS (Jordan et Rothschild, 1911). Text figs. 32 and 33.

Fourth joint of labial palpus on a level with base of fore trochanter, fifth joint twice length of fourth. Pronotal comb composed of eighteen to twenty spines. Posterior margin of hind coxa of male incurved from one-fourth of margin to center. Hind tarsi with long and wavy bristles in male. Dorsal apical bristles of second and third hind tarsal segments of male fanlike radiate, longest bristle about equalling third, fourth, and fifth segments together.

Male.—Abdominal tergites except first tergite each with two rows of bristles. 8*t* with about twenty bristles in upper half of apical lobe, none in lower half. 8*s* narrow, curved, ventrally bearing two bristles; distal portion membranous, divided into a large fringed ventral flap and several long dorsal filaments. Clasper small, process slightly club-shaped, located much below apex of finger. Finger large, somewhat pentagonal, anterior margin distinctly incurved, ventral portion conical, apex more or less truncate; membranous lobe or appendage rounded at apex. Dorsal center of finger provided with a row of short spinelike bristles. Anterior arm of 9*s* broad, curved; posterior arm relatively narrow and pointed at apex.

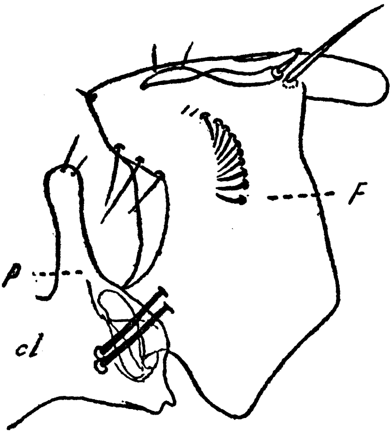


FIG. 32. *Paraceras crispus*, male. (After Jordan and Rothschild.)

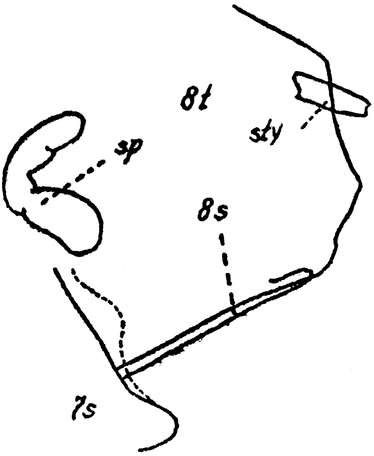


FIG. 33. *Paraceras crispus*, female. (After Jordan and Rothschild.)

Female.—Apex of 7*s* slanting, more or less undulating; ventral angle projecting out. 8*t* with four to seven bristles above stigma and below it one long bristle accompanied by one to four small bristles and twelve long bristles on lower half; apical margin angulate below middle. Spermatheca slender, with head shorter but slightly broader than tail.

19. PARACERAS SINENSIS (Liu, 1935). Text fig. 34.

This species was described under the genus *Oropsylla.* Later the eye dimensions, the length of the bristles of the second antennal segment, and other characters seemed to identify it as a member of *Paraceras* rather than of *Oropsylla.* Unfortunately the male is unknown.

Female.—Frontal tubercle prominent. Fourth joint of labial palpus reaching to middle of fore trochanter. One frontal bristle in front of anterior margin of antennal groove. Occiput with one small and one large bristle above middle of posterior margin composed of antennal groove. Pronotal comb composed of twenty-two spines. First seven abdominal tergites each with three rows of bristles. Apex of 7*s* with a conical ventral lobe.

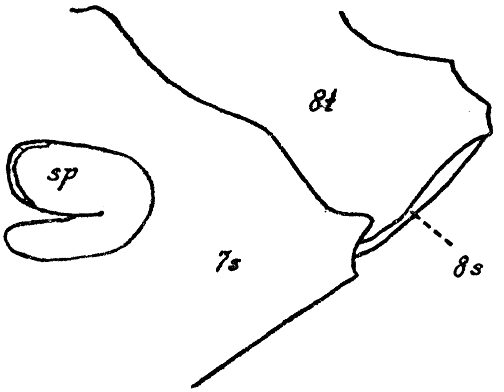


FIG. 84. *Paraceras sinensis*, female. (Author's drawing.)

8*t* with one strong bristle below stigma, about twenty-five bristles on lower half, and seven small bristles above stigma; apex, like that of *P. crispus*, angulate below middle. Head of spermatheca nearly as long as tail and less than twice as wide as tail, in one specimen head and tail nearly equal in length and width. A very large species, about 5 millimeters long.

6. Genus NEOCERATOPHYLLUS novum

Frontal tubercle prominent. Eyes well developed. Labial palpus reaching to base of fore trochanter. Ocular bristle located lower than upper margin of eye. Frontal row absent or rudimentary; only a few long setæ before anterior margin of antennal groove. First occipital row consisting of one bristle and second row of two bristles. Bristles of second antennal segment reaching beyond middle of club in male, but very short in female. Pronotal comb present. Outer surface of fore femur with few (one to four) small lateral bristles. Inner surface of mid- and hind coxæ without longish thin bristle. None of apical bristles of any tarsal segment reaching beyond apex of following segment. First pair of plantar bristles situated as laterally as other pairs.

Male.—One antepygidial bristle and two minute bristles. A short median process situated between two sets of antepygidial bristles. Inner side of 8*t* with spiculose area below dorsal margin. 8*s* broken up into whiplike laciniæ. Process of clasper hooked at apex. Finger long, with a ventral process

bearing three spiniform bristles. Coiling of ejaculatory duct incomplete (not more than one half). Anal sternite longer than tergite.

Female.—Three antepygidial bristles. Between two sets of antepygidial bristles a longer median process below which there is a distinct sinus. Stylet with one apical and one lateral (ventral) bristle. Head of spermatheca barrel-shaped, longer and broader than tail. Bursa copulatrix normal. Genotype: *N. trispinosus* sp. nov.

This new genus belongs to Jordan's group A (1932) or Ioff's subtribe Tarsopsyllini. It differs from the allied genera in that the first pair of plantar bristles of all tarsi is not situated in between the second pair. Regarding the genitalia it is in some respects allied to *Aceratophyllus* Ewing.

20. NEOCERATOPHYLLUS TRISPINOSUS sp. nov. Text figs. 35 and 36.

Head.—Frontal tubercle marked. Ocular row composed of three strong bristles. Obliquely above eye four smaller bristles in male and one in female, situated along anterior margin

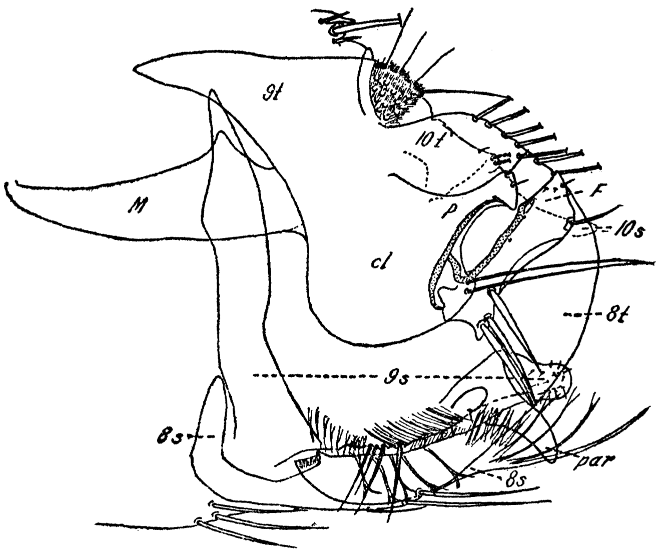


FIG. 35. *Neoceratophyllus trispinosus* sp. nov., male. (Author's drawing.)

of antennal groove. Small setæ present between bristles of ocular row and along anterior (middle part) and posterior margins of antennal groove. Occiput with first row represented by one bristle, second row by two bristles, of which lower is

rather stout, an apical row of five bristles on each side. Genal process acute. The proportional lengths of the four joints of the maxillary palpus are 27, 30, 24, and 36 in male and 23, 25, 22, and 30 in female.

Thorax.—Pronotum with a submedian row of five or six bristles on each side, with small setæ between them. Distance between bristles becoming gradually wider from dorsal side downwards. Pronotal comb consisting of eight spines on each

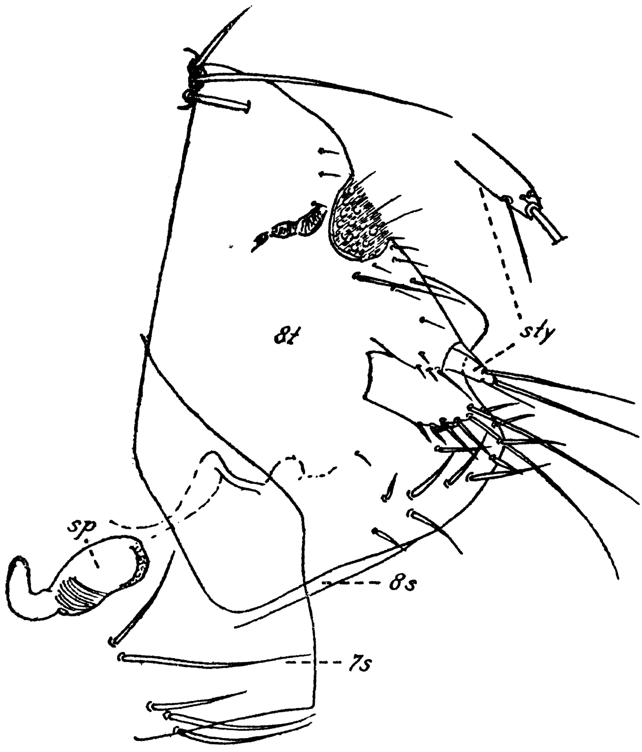


FIG. 36. *Neoceratophyllus trispinosus* sp. nov., female. (Author's drawing.)

side, lowest two spines distinctly smaller. Mesonotum with three rows of bristles: two, six or seven, five (apical row) on each side. Mesepisternum with two bristles in male and three in female. Mesepimeron with a row of three strong bristles. Metanotum with three rows of bristles: one, six to eight, five (apical row). Metepisternum with three or four bristles, metasternum with one to three very stout bristles, and metepimeron with three rows of strong bristles (two, two, one). Metanotum with a sclerotized tooth behind apical row, near dorsal margin.

Legs.—Fore femur with one to four lateral bristles (three in holotype and two in allotype) and, in addition, about seventeen small bristles in male and eleven in female, forming a dorsal and subdorsal row and a lower apical bristle. Hind tibia with eight pairs of spines along dorsal margin, second, fifth, and eighth pairs very stout. None of apical bristles of any tarsal segment reaching beyond apex of following segment.

Proportional lengths of different tarsi of all legs as follows:

	1st.		2d.		3d.		4th.		5th.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Fore tarsi	21	17	30	19	21	17	17	13	38	35
Midtarsi	43	37	40	35	28	25	19	15	38	35
Hind tarsi	97	80	68	55	45	36	24	20	44	42

Abdomen.—All tergites each with two rows of bristles, first row consisting of small bristles, apical row of strong bristles alternating with small setæ. Bristles of each row on each side of abdominal tergites as follows: first tergite 5, 5, with two apical teeth in male, and 3, 4, with one apical tooth in female; second tergite 6, 7 in male, and 5, 6 in female, with three apical teeth in both sexes and with lowest bristle of second row situated just below stigma; third tergite 5, 7 with two apical teeth in male, and 6, 6 with one apical tooth in female, in both sexes lowest bristle of second row situated below stigma; fourth tergite 5, 7, with two apical teeth in male, and 5, 6, with one apical tooth in female; fifth tergite 6, 7, with one apical tooth in male, and 5, 6, without apical tooth in female; sixth tergite 6, 7 in male and 4, 6 in female, in both sexes without apical tooth; seventh tergite 4, 7 in male, and 3, 5 in female, in both sexes without apical tooth. First two basal sternites without bristles, bristles of other sternites as follows: third sternite 2 in both sexes; fourth sternite 2 in both sexes; fifth sternite 2 in both sexes; sixth sternite 2 in male and 3 in female; seventh sternite 3 in male and 5 in female.

Modified segments.—Apex of 7*t* with a short process projecting backwards between two sets of antepygidial bristles. One long antepygidial bristle and two very minute bristles. 8*t* with a band of spiculose area below dorsal margin on inner side, seven bristles along dorsal margin, about nine bristles on subdorsal part above stigma, and nine more bristles on central or lower portion below stigma: apex rounded in outline. 8*s* rather broad, at distal apex with two ventral bristles, a fringed membranous lobe, and some filaments. Process of clasper long, dilated (hooked) at apex which bears two bristles. Two ace-

tabular bristles present. Manubrium of clasper tapering toward end. Movable finger slender, with apex slightly dilated and at lower ventral process with two stout spiniform bristles, slightly above them another spiniform bristle. The name of the species is derived from these three spinelike bristles. 9*s* with anterior arm tapering proximally; posterior arm terminating at a rounded membranous apex. Anal tergite slightly concave dorsally, at apex bearing a number of bristles. Anal sternite triangular, posterior angle much prolonged, with about twelve bristles on dorsal margin and a number of short bristles at apex.

Female.—Three antepygidial bristles. Process between two sets of antepygidial bristles longer than that of male, with a distinct excision below process. Apex of 7*s* with an upper shallow incurving and a more or less truncate lower lobe. 8*t* with three small bristles above stigma and one large bristle below stigma or pygidium. Apex of 8*t* with a deep sinus, lower lobe wider, with five spiniform bristles along apical margin and four more spiniform bristles and three bristles near apex. 8*s* narrow. Stylet with one apical bristle and with one lateral bristle on ventral margin. 10*s* distinctly angulate along ventral margin, along ventral apical margin with six strong bristles. Head of spermatheca barrel-shaped, concave above and concave below, much longer and wider than tail.

Length, male, 2.5 millimeters; female, 2.7.

Holotype, male, and allotype, female, and fifteen paratypes: Two males and thirteen females, all taken by myself off a squirrel, *Sciurus* sp., at Tien Mo Shan, Chekiang, August 17, 1936. In the author's collection.

7. Genus ACERATOPHYLLUS Ewing, 1929

Frontal tubercle marked and placed farther up. Frontal row wanting or rudimentary, few setæ in front of anterior margin of antennal groove. Labial palpus reaching to apex of fore coxa or trochanter. Occiput usually with three bristles (two incomplete rows) besides apical row. Bristles of second antennal segment of female reaching almost to or a little beyond club. Fifth segment of all tarsi with basal pair of plantar bristles shifted ventrad, situated in between second pair.

Male.—One long antepygidial bristle and two small stiff hairs. 8*s* broken up into whiplike laciniæ. Clasper with long process hooked at apex. Two strong acetabular bristles located not higher than hinge of movable finger. Finger boot-shaped, with

one bladelike bristle near distal apex and a group of two to four very stout bristles at heel (lower ventral process). 9*t* extending farther frontad, sometimes beyond distal apex of manubrium. Manubrium dorsally not far from base, with a rounded hump. Apex of 9*s* with a knifelike bristle.

Female.—Three antepygidial bristles. Head of spermatheca barrel-shaped or somewhat globular.

When Ewing established this genus in 1929, he took as the genotype *A. javanicus* Ewing which, unfortunately, was regarded by Jordan as a species of *Paraceras*. I am of the opinion that *A. fimbriatus* (Jordan et Rothschild, 1921), should be designated as the genotype, and am inclined to include three other species into this genus: *A. lupatus* (Jordan et Rothschild, 1921), *A. euteles* (Jordan et Rothschild, 1911), and *A. phillipsi* (Jordan, 1925). In order to meet the present situation the description of the genus has been greatly modified. This genus is closely related to *Macrostylophora* Ewing, 1929, which was erected for *C. hastatus* Jordan et Rothschild, 1921. It can be distinguished from the above genus by the absence of the median process between the antepygidial bristles and the presence of a bladelike bristle near the apex of the ninth sternite.

21. ACERATOPHYLLUS EUTELES (Jordan et Rothschild, 1911). Text figs. 37 and 38.

Frontal tubercle marked, nearer to central sensory organ than to oral angle. Frontal row composed of one to three small bristles. Labial palpus reaching to apex of fore coxa. Pronotal comb consisting of eighteen spines. Meso- and metanota each with two rows of bristles and a few additional dorsal bristles forming a third row. Longest apical bristle of second hind tarsal segment one-third shorter than third segment.

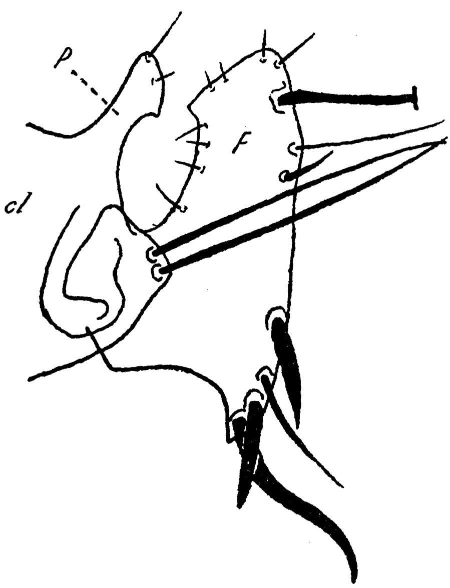


FIG. 37. *Aceratophyllus euteles*, male. (After Jordan.)

Male.—Process of clasper dilated at apex with a sharp lower angle. Finger peculiar in shape (text fig. 37); dorsal apex truncate, ventral apex concave; stout spiniform bristles present, long and wavy.

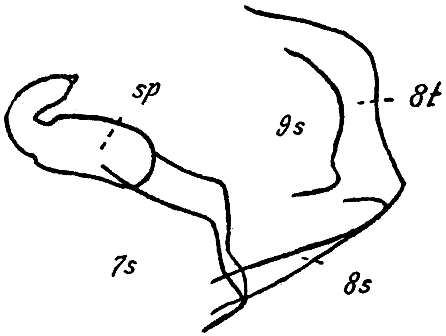


FIG. 38. *Aceratophyllus euteles*, female. (After Jordan and Rothschild.)

Female.—Apical margin of 7*s* either slightly incurved or slanting. 8*t* with one long and two short bristles below stigma, seven to ten bristles in ventral half; apex gently incurved, upper angle rounded. Head cylindrical, longer than tail.

8. Genus PARADOXOPSYLLUS Miyajima et Koidsumi, 1909

The original description of the genus was apparently lost and unknown to the world until 1934. It was written in Japanese and published in the Journal of Bacteriology. When Miyajima and Koidsumi first established the genus they gave the following generic characters: (*a*) incomplete pigmentation of eye, (*b*) one acetabular bristle (with exceptions at present), (*c*) presence of pronotal comb, and (*d*) five pairs of plantar bristles. At present other characters are shown to be of generic importance: frontal tubercle frequently wanting; labial palpus not reaching beyond fore trochanter; ocular bristle situated above eye on margin of antennal groove; bristles on second antennal segment not long in male; prefrontal row of bristles wanting; only a vestigial occipital row of bristles; first hind tarsal segment shorter than second, third, and fourth segments combined; first pair of plantar bristles of fifth hind tarsal segment situated laterally, like others.

Male.—One or both outer two of the three antepygidial bristles minute or wanting. 8*s* large and wide.

Female.—Spermatheca with a globose head and a saclike tail.

Key to the species of Paradoxopsyllus.

1. Longest apical bristle of second hind tarsal segment reaching to middle of fifth segment or projecting beyond fifth segment. Male, one acetabular bristle. Finger widest at middle, tapering towards apex. 8*t* with a lateral patch of sixteen to eighteen strong bristles. Female, apex of 7*s* with a slightly excurved lobe.. 2.
   Longest apical bristle of second hind tarsal segment reaching to apex of third segment or a little beyond third segment. Male, two acetabular

bristles. Finger of even width. 8*t* without lateral patch of long bristles. Female, apex of 7*s* with a distinct small sinus.
P. custodis Jordan.

2. Frontal tubercle marked. No hairs above antennal groove. Middle tergites each with a posterior row of five or six bristles on each side.
P. curvispinus Miyajima et Koidsumi.

Frontal tubercle feebly developed. Some hairs above antennal groove and some in form of shortened bristles. Middle tergites each with a posterior row of seven bristles.............................. *P. conveniens* Wagner.

22. PARADOXOPSYLLUS CURVISPINUS Miyajima et Koidsumi, 1909. Text figs. 39 and 40.

FIG. 39. *Paradoxopsyllus curvispinus*, male, variations. (*A*, After Miyajima and Koidsumi; *B*, after Rothschild.)

Front vertical from tubercle downward. Eye round, very feebly pigmented. Frontal row of three or four bristles. Bristles of second antennal segment minute in both sexes. Labial palpus extending to fore trochanter. Occiput with one stout bristle behind middle of antennal groove. Pronotal comb composed of eighteen pointed spines. Longest apical bristle of second hind tarsal segment (one in female and three in male) extending to middle of fifth segment or beyond; third segment of male about twice as long as fourth segment. Middle abdominal tergites bearing each a posterior row of five or six (mostly six) large bristles.

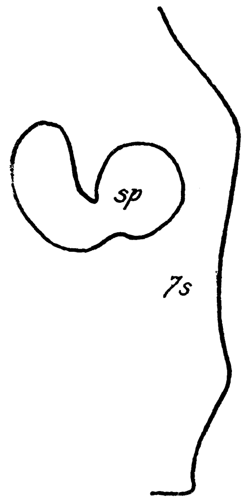


FIG. 40. *Paradoxopsyllus curvispinus*, female. (After Rothschild.)

Male.—Two antepygidial bristles, upper bristle about one-half as long as middle

bristle. 8*s* rather large, not very much smaller than tergite, produced ventrally into a pointed lobe bearing one to four bristles, besides a dozen smaller bristles. Manubrium of clasper terminating in a slender point. Dorsal posterior portion of clasper forming a broad process. Finger thumblike, widest at middle, strongly rounded along posterior margin. One long acetabular bristle. 9*s* exceedingly slender, posterior arm bearing two long bristles near middle.

Female.—Three antepygidial bristles, lowest bristle shortest. Apex of 8*s* more or less truncate in outline, except two slight incurvings. Apical margin of 8*t* rounded and slightly undulate, with lower angle projecting. Stylet about twice as long as basally broad. Spermatheca with globular head and broad tail.

22. PARADOXOPSYLLUS CUSTODIS Jordan, 1932. Text figs. 41 and 42.

Closely allied to *P. curvispinus* Miyajima et Koidsumi. Frontal row composed of six (in male and two in female) bristles.

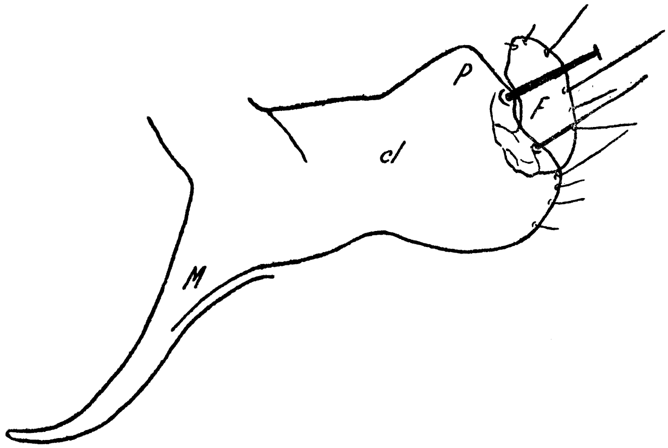


FIG. 41. *Paradoxopsyllus custodis*, male. (After Jordan.)

Occiput with three bristles behind middle of antennal groove. Hind tibia with nine dorsal notches, third, sixth, and seventh of which bear one bristle each; longest dorsal apical bristle of hind tibia not extending to apex of first hind tarsal segment; longest bristle of first segment extending to subapical notch of second segment, longest apical bristles of second segment reaching to apex of third segment or a little beyond. Middle abdominal tergites bearing each a posterior row of five or six bristles.

Male.—8*t* with three or four small bristles above stigma and two very long bristles below, without a lateral patch of long

bristles. Clasper more than twice as long as broad at narrowest point, rounded ventroposteriorly and enlarged into a broad process. Manubrium slender. Angle between inner frontal portion of 9*t* and manubrium very obtuse. Two acetabular bristles, long upper bristle shifted well above acetabulum, lower bristle much smaller. Finger of even width, strongly curved at base, apex obliquely truncate on anterior side. Frontal margin of proximal apex of anterior arm of 9*s* concave; apical lobe of posterior arm round at apex, irregularly long-ovate.

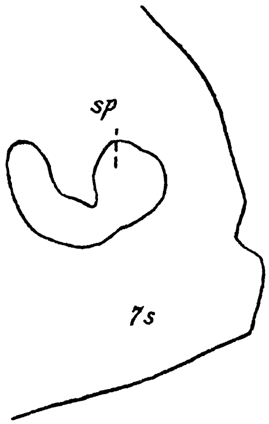


FIG. 42. *Paradoxopsyllus custodis*, female. (After Jordan.)

Female.—7*s* with a small sinus below middle of apical margin. 8*t* with two or three bristles above stigma, one long and one small bristle below stigma, eight or nine on lower area and two or three inside, of which one is marginal. Spermatheca with a subglobular head and a long tail. Duct of bursa copulatrix strongly curved in middle, bursa rather large.

24. PARADOXOPSYLLUS CONVENIENS Wagner, 1929.

Female.—Frontal tubercle feebly developed. On upper margin of antennal groove six or seven hairs, hind one or two of which are in the form of shortened bristles. Longest dorsal apical bristle of hind tibia extending beyond apex of first hind tarsal segment; longest bristle of first segment extending beyond apex of second segment; two apical bristles of second segment extending to middle of fifth segment or beyond. Middle abdominal tergites bearing each a posterior row of seven large bristles. Apical margin of 7*s* bearing a small evagination. 8*t* bearing below stigma two or three stout bristles, one to three smaller bristles, and, apart from marginal bristles, nine to eleven lateral bristles.

9. Genus OPHTHALMOPSYLLA Wagner et Ioff, 1926

Frontal tubercle small. Labial palpus not reaching beyond fore trochanter. Ocular bristle situated above upper margin of eye. Prefrontal row wanting. Eye very peculiar in that it consists of a larger, upper, lightly pigmented portion and a

smaller, lower, deeply pigmented portion which appears as an appendage or a second eye to upper eye. This second eye smaller in male. Upper eye often provided with a sinus which is more pronounced in male. Bristles of second antennal segment in female not long. Antepygidial bristles three in both sexes, spinelike in male.

Male.—Posterior margin of clasper with an acetabular projection on which is a very stout bristle. 8*s* feebly developed.

Female.—Head of spermatheca pyriform, narrowing toward distal end.

Key to the species of Ophthalmopsylla.

1. Frontal tubercle normal in shape and position. First hind tarsal segment shorter than second to fourth segments together .... 2.
   Frontal tubercle rounded and close above oral corner. First hind tarsal segment equalling second to fourth segments together. Finger with blunt spiniform .... *O. jettmari* Jordan.
2. Longest apical bristle of second hind tarsal segment extending to apex of fourth. Male, apical half of finger nearly square, with two normal spiniforms at posterior angle. Acetabular projection not very narrow. Female, apex of 7*s* with a broad, shallow upper sinus. *O. kukuschkini* Ioff.
   Longest apical bristle of second hind tarsal segment extending beyond apex of fourth. Male, apical half of finger nearly ax-shaped, with a twisted spiniform at posterior angle. Acetabular projection narrow. Female, apex of 7*s* with a deep lower sinus .... 3.
3. Pronotal comb consisting of eighteen to twenty spines. Metepimeron with seven or eight bristles. Male, finger resembling an inverted bell, with twisted spiniform. Female, apex of 7*s* with a semicircular sinus, upper lobe rounded, lower lobe pointed .... *O. præfectus pernix* Jordan.
   Pronotal comb composed of twenty-four or twenty-five spines. Metepimeron with twenty-three bristles arranged in five vertical rows. Male unknown. Female, apex of 7*s* with an elongate semicircular sinus, upper lobe sharply pointed, lower lobe more or less truncate. *O. kiritschenkoi* Wagner.

25. OPHTHALMOPSYLLA PRÆFECTUS PERNIX Jordan, 1929. Text figs. 43 and 44.

Front with a row of five small bristles above an ocular row of three strong bristles. Labial palpus reaching to fore trochanter but not beyond it, a little longer than maxillary palpus. Eye with black-pigmented inside deeply sinuated. Bristles of second antennal segment short in both sexes. Pronotal comb composed of eighteen to twenty spines. Metepimeron with seven or eight bristles. Second hind tarsal segment in male with two, in female with three, long apical bristles reaching beyond apex of fourth segment. Proximal pair of plantar bristles of all tarsi entirely lateral.

Male.—Clasper with dorsal portion produced into a slender process; lower angle also produced into a short process which bears a long acetabular bristle. Finger shaped like an inverted

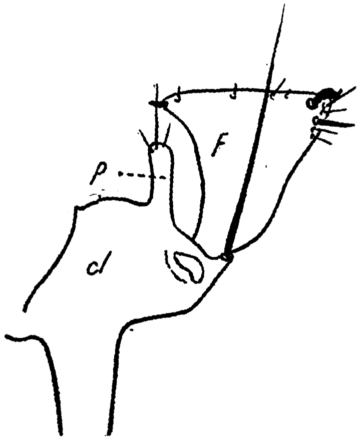


FIG. 43. *Ophthalmopsylla præfectus pernix*, male. (After Jordan.)

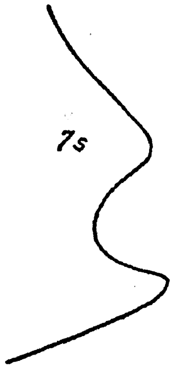


FIG. 44. *Ophthalmopsylla præfectus pernix*, female. (After Jordan.)

bell, widest at apex; anterior apical angle bearing a short pale spine, posterior apical angle bearing a strong twisted pointed spiniform below, close to which is a subspiniform.

Female.—Apex of 7*s* with a rounded, rather deep sinus. 8*t* below stigma with two long and three or four short bristles. Stylet a little more than twice as long as broad at base. Spermatheca with a pyriform head about as long as tail.

26. OPHTHALMOPSYLLA KUKUSCHKINI Ioff, 1927. Text fig. 45.

Resembles somewhat *O. præfectus* Jordan et Rothschild. Longest apical bristle (ventral) of second hind tarsal segment reaching only to apex of fourth segment, dorsal bristle just exceeding apex of third segment.

Male.—Upper process of clasper rounded off at apex; lower acetabular projection not so narrowed as in *præfectus*. Finger

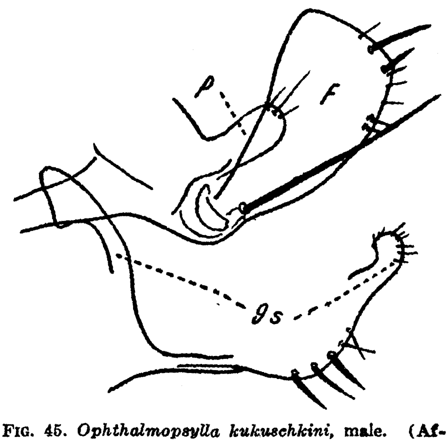


FIG. 45. *Ophthalmopsylla kukuschkini*, male. (After Ioff.)

with distal half more or less square, anterior margin more or less straight, hind margin gradually convex, two apical corners not acute, spiniforms not twisted. 9*s* with a row of stout bristles along centro-ventral margin of posterior arm.

Female.—Apex of 7*s* with a broad shallow upper sinus, angle above sinus very obtuse and strongly rounded, lobe below sinus projecting out considerably, broad, apically emarginate, with upper angle strongly rounded.

27. OPHTHALMOPSYLLA JETTMARI Jordan, 1929. Text figs. 46 and 47.

Frontal tubercle rounded. Pronotal comb with twenty-four or twenty-five spines. Eighteen to twenty-six bristles on met-

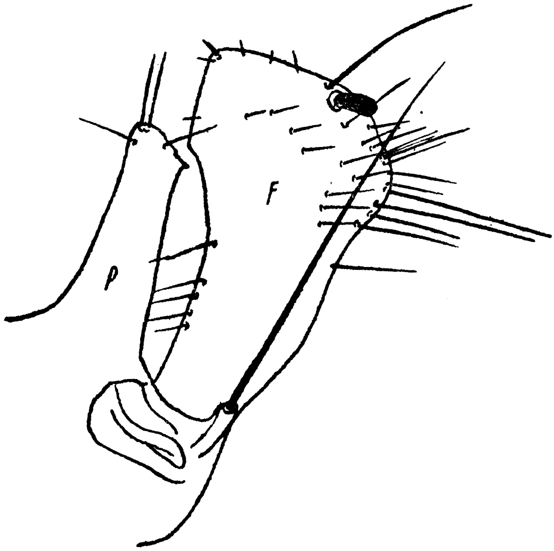


FIG. 46. *Ophthalmopsylla jettmari*, male. (After Jordan.)

epimeron. Metanotum bearing on each side three or four blackish apical spines. First hind tarsal segment equaling second to fourth segments together. Longest dorsal bristle of second hind tarsal segment in male reaching to, or beyond, apex of fifth segment, and in female reaching not quite to apex of fourth segment.

Male.—8*t* with forty bristles below stigma. Upper process of clasper stout and truncate at apex; lower acetabular projection short, cylindrical, bearing a long bristle. Finger a little more than twice as long as broad; anterior apical angle 90°; posterior apex widened into a convex lobe, above which is a

claviform or blunt spiniform. Posterior arm of 9*s* with a double row of ten long bristles.

Female.—Apical margin of 7*s* slanting, with a broad shallow oblique sinus below which the segment is subtruncate. Spermatheca resembling that of *O. præfectus;* sclerified portion of bursa copulatrix elbowed.

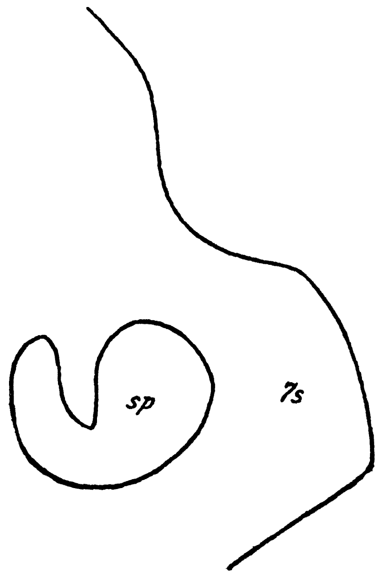


FIG. 47. *Ophthalmopsylla jettmari*, female. (After Jordan.)

28. OPHTHALMOPSYLLA KIRITSCHENKOI Wagner, 1929. Text fig. 48.

Female.—Frontal row consisting of three lower bristles. Bristles of second antennal segment small. First occipital row either entirely missing or replaced by a small bristle. Pronotal comb consisting of twenty-four or twenty-five spines. Metepimeron with about twenty-three bristles arranged in five irregular rows. Outer surface of hind tibia provided with twenty-six to twenty-nine bristles, of which posterior eighteen form two complete rows. Two apical bristles of second hind tarsal segment reaching beyond apex of fourth segment. Apical margin of 7*s* with a deep sinus dividing apex into a long, narrow acute upper lobe and a short, blunt, lower lobe. 8*t* bearing about twenty-three substigmal bristles which form three rows; before and above stigma are dense small bristles. Stylet short, conical.

FIG. 48. *Ophthalmopsylla kiritschenkoi*, female. (After Wagner.)

10. Genus FRONTOPSYLLA Wagner et Ioff, 1926

Frontal tubercle conical. Lower portion of front slightly prolonged or extended behind. Frontal row complete. Prefrontal row wanting. Ocular row composed of three or four bristles. Ocular bristle situated above eye on margin of antennal groove. Sometimes a bristle between frontal and ocular row. Bristles of second antennal segment not long in male. Labial palpus

not lengthened, not reaching beyond trochanter. Two occipital rows of bristles well developed; second row always complete. First hind tarsal segment shorter than second, third and fourth segments combined. First pair of plantar bristles on fifth tarsi situated laterally, like other pairs. Antepygidial bristles three in both sexes, one or two of those of male minute or wanting.

Male.—*8t* short, length deeply broken behind. *8s* broad. Upper acetabular bristle shifted considerably upward.

Female.—No distinct boundary between head and tail of spermatheca.

Key to the species of Frontopsylla.

1. Pronotal comb composed of twenty-four spines. Female, apex of *7s* not sinuate .... *F. hetera* Wagner.
   Pronotal comb composed of eighteen to twenty spines. Female, apex of *7s* distinctly sinuate .... 2.
2. Ocular row composed of four bristles, one less developed. Middle abdominal tergites with three more or less developed rows of bristles. Male, posterior and apical margins of finger evenly rounded in form of a semicircle. Female, apex of *7s* with a wide sinus. *F. wagneri* Ioff.
   Ocular row composed of three bristles. Middle abdominal tergites with two rows of bristles, although few frontal small bristles may be present. Male, posterior margin of finger slightly incurved, apical margin more or less truncate. Female, apex of *7s* with a narrow sinus........ 3.
3. Longest apical bristle of second hind tarsal segment reaching beyond third segment in female and beyond fourth segment in male. Male, process of clasper long, apex reaching beyond middle or even beyond apex of finger. Posteroapical spiniform of finger short, blunt, often widest at center. *8s* not bearing four spiniform bristles at apex...... 4.
   Longest apical bristle of second hind tarsal segment not reaching beyond apex of third segment in female. Male, process of clasper very short, apex not reaching beyond middle of finger. Posteroapical spiniform of finger long, acute, widest at base. *8s* bearing four spiniform bristles besides other bristles at apex............ 6. *F. spadix* Jordan et Rothschild.
4. Male, process of clasper relatively short, reaching three-fourths length of anterior margin of finger. Setose ventral area of *9s* with a spiniform placed nearer distal bristle. Female, apex of *7s* with a sinus which is much wider than lower lobe........ *F. elata botis* Jordan.
   Male, process of clasper long, either reaching to nine-tenths length of anterior margin of finger or projecting beyond latter. Setose ventral area of *9s* with a spiniform about midway between proximal and distal bristles. Female, apex of *7s* with a sinus as wide as lower lobe. 5. *F. luculenta* Jordan et Rothschild.
5. Male, process of clasper located a little below anterior apex of finger. *F. luculenta luculenta* Jordan et Rothschild.
   Male, process of clasper a little above anterior apex of finger. *F. luculenta parilis* Jordan.

6. Male, posteroapical spiniform of finger shorter. Apex of finger a little narrower. Female, apex of 7s with a shallow sinus, upper lobe broader than lower.................................... *F. spadix spadix* Jordan et Rothschild.
   Male, posteroapical spiniform of finger longer. Apex of finger one-sixth or one-seventh wider. Female, apex of 7s with a deeper sinus, upper lobe narrower than lower.. *F. spadix cansa* Jordan.

29. **FRONTOPSYLLA ELATA BOTIS Jordan, 1929. Text figs. 49 and 50.**

Allied to *F. elata elata* (Jordan et Rothschild, 1915), which is characterized by the following description: Frontal row composed of six to eight bristles. Ocular row composed of three bristles. Two occipital rows of bristles (four, six) and an apical row of six bristles. Pronotal comb consisting of nineteen or twenty spines. Metepimeron with four to six long bristles. Longest apical bristle of second hind tarsal segment

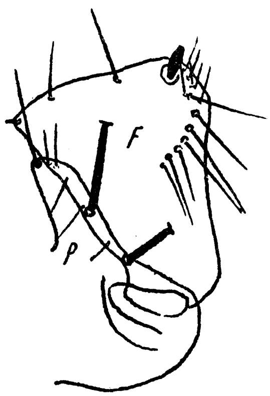


FIG. 49. *Frontopsylla elata botis*, male. (After Jordan.)

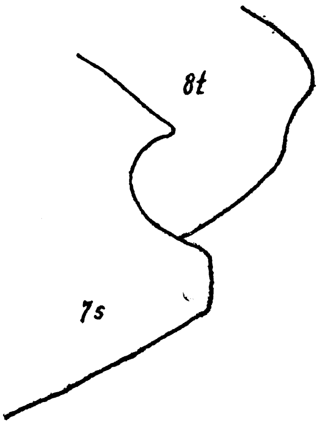


FIG. 50. *Frontopsylla elata botis*, female. (After Jordan.)

reaching beyond apex of fourth segment in male, shorter in female. Middle abdominal tergites with only two rows of bristles, sometimes a few frontal bristles present.

Male.—8*t* with nineteen to twenty-four bristles. 8*s* large, conical in outline, with a number of bristles at apical portion. Process of clasper acuminate at apex, slightly shorter than frontal margin of finger. Finger widest at apex which is more or less truncate, with a spiniform at distal apical angle. Proximal apex of 9*s* rectangular; 9*s* without an excision beyond setiferous area, with one short spiniform at distal end of setose area; hind margin of posterior arm of 9*s* almost straight. Anal tergite bearing two small spiniforms and several apical spines. 8*t* bearing long bristles, alternating with shorter and thinner bristles. Process of clasper shorter, apex located about one-

fourth distance below apex of finger. Apical margin of finger shorter, posterior margin but slightly incurved.

Female.—Apex of 7s with a sinus dividing it into an upper pointed lobe and a broad lower, rounded-truncate lobe, upper lobe as long as lower lobe. Spermatheca truncate, head about one-third longer than broad. 7s resembling *F. elata elata,* except that the lower lobe is rather convex. "Below stigma of VIII. t. 1 long bristle and 1–3 short ones; on the widened lower and apical portion 14–19 bristles, there being a wide gap between these bristles and those below the stigma."

Frontopsylla elata botis differs from the preceding subspecies especially in the male.

30a. FRONTOPSYLLA LUCULENTA LUCULENTA (Jordan et Rothschild, 1923). Text figs. 51 and 52.

Frontal row composed of five to seven bristles, ocular row composed of three bristles. Occiput with two rows of bristles

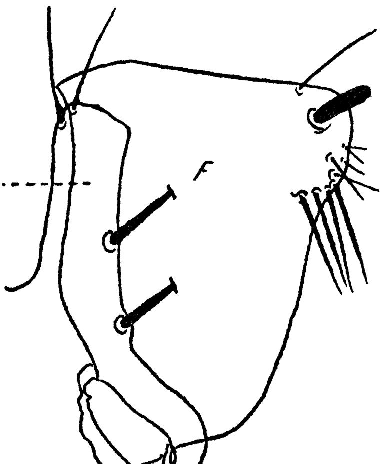


FIG. 51. *Frontopsylla luculenta luculenta,* male. (After Jordan and Rothschild.)

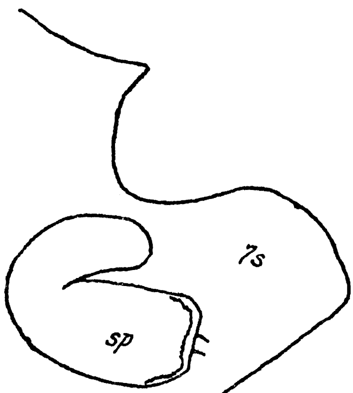


FIG. 52. *Frontopsylla luculenta luculenta,* female. (After Jordan and Rothschild.)

(four or five, five or six) besides apical row. Pronotal comb composed of twenty spines. Mesonotum with four rows of bristles, metanotum with three rows of bristles. Metepimeron with three rows of bristles (four, five, one or two). Longest apical bristles of second hind tarsal segment reaching beyond apex of fourth segment in male and third segment in female.

Male.—8s even more bristly than *F. elata elata,* there being numerous long submarginal and marginal bristles besides small

ones. Process of clasper broader, truncate at apex. Inner surface of finger also fringed with hairs. Hind margin of posterior arm of 9*s* much convex, setose posterior area with a short spiniform about midway between most proximal and most distal spiniform.

Female.—Apex of 7*s* with a deep sinus dividing it into an upper pointed lobe and a broad, lower rounded-truncate lobe, upper lobe considerably shorter than lower. Spermatheca with tail a little shorter than that of *F. elata elata.*

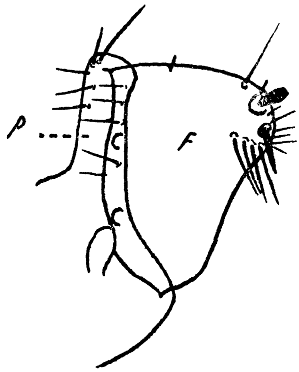


FIG. 53. *Frontopsylla luculenta parilis,* male. (After Jordan.)

30b. FRONTOPSYLLA LUCULENTA PARILIS Jordan, 1929. Text fig. 53.

Apparently differing from *F. luculenta luculenta* only in male. Process of clasper longer, reaching a little above, or to anterior apical angle of movable finger.

31. FRONTOPSYLLA WAGNERI Ioff, 1927. Text figs. 54 and 55.

Frontal row composed of six to eight bristles. Ocular row composed of four bristles, fourth bristle set between the two lower bristles and less developed. Occiput with two rows of bristles (four to seven, six or seven), apex with one row. Pronotal comb composed of eighteen to twenty spines. Middle abdominal segments with three more or less developed rows of bristles, being more bristly than *F. elata* and *luculenta.*

Male.—Process of clasper rather short, about one-half as long as finger, rounded at apex. Finger much longer than process, crescent in outline with posterior margin strongly rounded; a spiniform present a little beyond middle of posterior margin from base. Posterior arm of 9*s* weakly developed, with few small bristles on posterior margin, short spiniform lacking.

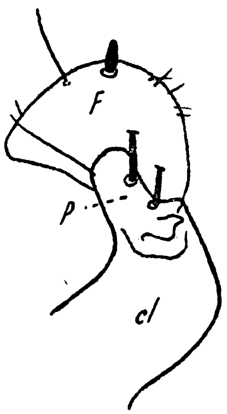


FIG. 54. *Frontopsylla wagneri,* male. (After Ioff.)

Female.—Apex of 7*s* with a very wide sinus dividing it into an upper pointed lobe and a lower rounded or truncate lobe,

sinus much wider than lower lobe. Spermatheca similar to that in the preceding species.

FIG. 55. *Frontopsylla wagneri*, female, variations of seventh sternite. (After Ioff.)

32. FRONTOPSYLLA HETERA Wagner, 1932. Text fig. 56.

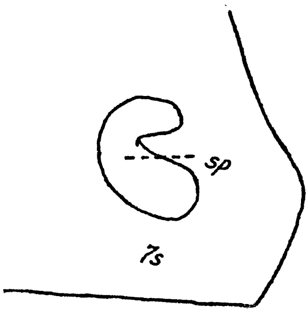


FIG. 56. *Frontopsylla hetera*, female. (After Wagner.)

Female.—Occipital rows consisting of four to six bristles. Pronotal comb composed of twenty-four spines. Pronotum as long as spine. Two apical bristles of second hind tarsal segment reaching to middle of fourth segment. Lowest bristle on fourth to seventh abdominal tergites considerably weaker than rest, situated below stigma on fourth to sixth abdominal tergites, above stigma on seventh. Apex of 7*s* more or less rounded-truncate. 8*t* with one long bristle below stigma and seven long bristles at lower apical portion. Stylet narrower.

33a. FRONTOPSYLLA SPADIX SPADIX Jordan et Rothschild, 1921. Text fig. 57.

Frontal row composed of six bristles, ocular row of three bristles. Occiput with two rows of bristles (two, six) and an apical row of seven bristles. Pronotal comb composed of twenty spines. Meso- and metanota with three rows of bristles. Metepimeron with seven or eight bristles. Longest bristle of second hind tarsal segment not reaching beyond apex of third segment. Apical margin of first to fourth abdominal segments dorsally denticulate.

Male.—Genitalia similar to those in *F. spadix cansa.* Apex of 8*s* with four stout spiniforms. Process of clasper short,

reaching to a little below middle of finger. Manubrium broad at base, abruptly narrow towards apex. Finger resembling an inverted bell in outline, with a narrow base; anterior margin evenly concave; apical margin evenly convex; a stout spiniform at posterior apical angle; both anterior and posterior apical angles acute or less than 90°. Proximal apex of anterior arm of 9*s* in the shape of a goose head.

Female.—Apex of 7*s* with a shallow sinus dividing it into two broadly rounded lobes, upper lobe broad, lower lobe rounded. 8*t* with six to eight small bristles above stigma, one large and two to four small bristles below stigma. Spermatheca with elongate head and short broad tail.

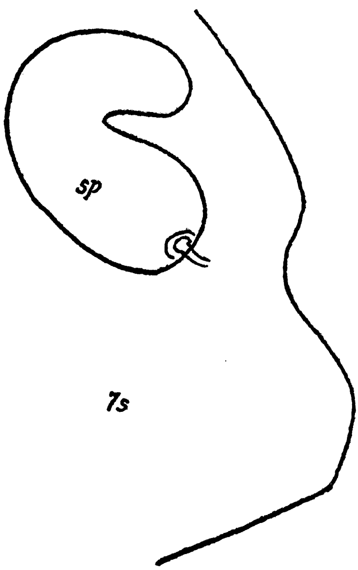


FIG. 57. *Frontopsylla spadix spadix*, female. (After Jordan and Rothschild.)

33b. FRONTOPSYLLA SPADIX CANSA Jordan, 1932. Text figs. 58 and 59.

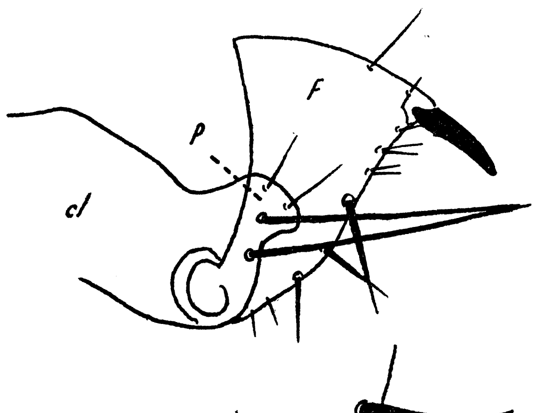


FIG. 58. *Frontopsylla spadix cansa*, male. (After Jordan.)

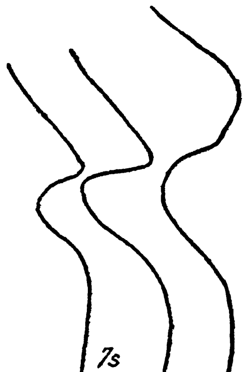


FIG. 59. *Frontopsylla spadix cansa*, female, variations of seventh sternite. (After Jordan.)

Closely related to *F. spadix spadix*. Male, finger apically about one-sixth to one-seventh wider, large apical spiniform longer. Female, sinus of 7s deeper; upper lobe longer, often pointed at apex, lower lobe much broader than upper.

11. Genus GEUSIBIA Jordan, 1932

Frontal tubercle prominent. Ocular row composed of three bristles. Labial palpus reaching to near two-thirds length of fore coxa in male, five-sixths in female. Tibia and first tarsal segment of all legs densely hairy on dorsal margin besides bearing long bristles. First pair of plantar bristles of fifth tarsal segment distinctly bent mediad. Antepygidial bristles, none in male and three in female. 7*t* bearing median process which is short in female and long in male, here reaching a little beyond middle of pygidium.

Male.—Both 8*t* and 8*s* large, former conical, without a row of marginal bristles; 8*t* dorsolaterally with an elongate horizontal sclerite which bears a condylus; 8*s* with two rodlike incrassations on each side. Process of clasper broad, conical, and as long as finger. Apex of anterior arm of 9*s* broad, truncate-emarginate, with upper and frontal angles distincly projecting.

Female.—Orifice of spermatheca on a prominent cone projecting downwards.

34. GEUSIBIA TOROSA Jordan, 1932. Text figs. 60 and 61.

Frontal row composed of five or six bristles. Occiput with three rows of bristles. Pronotal comb composed of twenty to

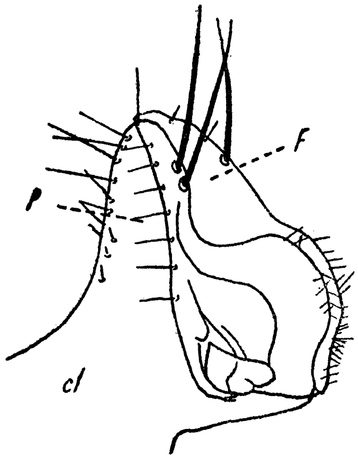


FIG. 60. *Geusibia torosa*, male. (After Jordan.)

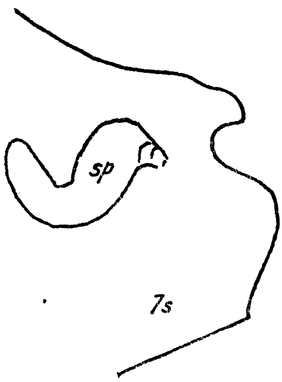


FIG. 61. *Geusibia torosa*, female. (After Jordan.)

twenty-two spines. Mesonotum with one short stout apical spine on each side. First abdominal tergite with three rows and some additional dorsal bristles, the other tergites with two rows.

Male.—8*t* forming an equilateral triangle with apex rounded off and bearing fifteen long bristles on side. 8*s* with a vertical proximal margin provided with rodlike incrassations in the form of an equilateral triangle; ventral margin gently rounded; apical margin subtruncate, bearing five spiniforms and a proximal patch of fifteen very short, obtuse conical spiniforms. Process of clasper broad, conical, as long as finger; lower half of posterior margin of clasper and finger feebly sclerotized and hairy. Apex of anterior arm of 9*s* broad, truncate-emarginate, with upper and frontal angles distinctly projecting; ventral process resembling head of a bird and bearing several small hairs and one bristle.

Female.—7*s* with sinus dividing it into a narrow, pointed upper lobe and a broad, rounded lower lobe. On 8*t* above stigma four to seven small bristles, below stigma three large bristles (rarely two), on lower surface eleven to fifteen, on inside two or three, apex of 8*t* sinuate. 8*s* broad. Head of spermatheca not sharply divided from tail.

12. Genus AMPHIPSYLLA Wagner, 1908

Head with an angle under which it is extended toward the posterior side. Eye feebly developed, incompletely pigmented. Ocular bristle situated above upper margin of eye. Ocular row composed of two, seldom three, bristles. Frontal row complete. Bristles of second antennal segment short in both sexes. First hind tarsal segment shorter than second, third, and fourth segments combined. First pair of plantar bristles on fifth hind tarsal segment moved on to ventral surface, almost between second pair. Between long middle bristle and long apical bristle on hind margin of hind tibia three or four short, approximately equal bristles forming a comb. Three antepygidial bristles present in both sexes. Male, 8*s* wide. Clasper without acetabular bristles. Finger with spiniforms.

Key to the species of Amphipsylla.

1. Male, finger widest near middle, apex tapering towards end. 8*s* densely hairy, hairs on inner side of margin thin and wavy, those on outer side longer and thicker.............................. *A. casis* Jordan et Rothschild.

Male, finger widest at apex which is more or less rounded-truncate. 8s less hairy .... 2.

2\. Male, finger with a spiniform near base at ventroposterior corner. Female, apex of 7s truncate........ *A. tuta* Wagner.

Male, finger without spiniform near base. Female, apex of 7s not truncate .... 3.

3\. Male, finger with two apical spiniforms close together, none of spiniforms abruptly widest at center. 9s widening abruptly at apex. Female, apex of 7s distinctly notched........ *A. vinogradovi* Ioff.

Male, finger with two apical spiniforms far apart along posterior margin, upper spiniform abruptly widest at center. Female, apex of 7s either rounded or very slightly sinuate........ 4.

4\. Male, finger much longer and narrower; five thin marginal bristles between apical and submedian spiniforms. Posterior margin of clasper not sinuate. Female, apex of 7s rounded-convex.... *A. aspalacis* Jordan.

Male, finger shorter and wider; eight or nine thin marginal bristles between apical and submedian spiniforms. Posterior margin of clasper sinuate. Female, apex of 7s slightly concave........ *A. mitis* Jordan.

35. AMPHIPSYLLA TUTA Wagner, 1929. Text fig. 62.

Frontal tubercle lacking. First occipital row with one bristle, second with three bristles. Lower part of front in female distinctly slanting downward and rounded off toward apex, that in male rounded off from edge of mouth to base of antenna.

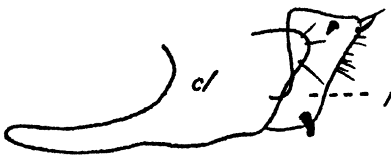


FIG. 62. *Amphipsylla tuta*, male. (After Wagner.)

Male.—8s bearing a pair of cylindrical processes, each of which has a long apical bristle. Clasper somewhat square in outline. Manubrium gradually tapering toward apex. Finger widest at apex, with a basal spiniform at ventroposterior corner, about eight bristles along upper posterior margin, one curved bristle on upper posterior apex, another small spiniform situated a little below apical margin.

Female.—Apex of 7s truncate.

36. AMPHIPSYLLA ASPALACIS Jordan, 1929. Text figs. 63 and 64.

First occipital row composed of one bristle. Three rows on mesonotum with additional dorsal bristles. Two rows on metanotum. Metepimeron with ten to thirteen bristles in male and twelve to sixteen in female.

Male.—Apex of 8s with long bristles. Clasper not square in outline. Finger widest at apex, upper anterior angle very obtuse; spiniform located on upper posterior angle of finger widest at center, another spiniform of ordinary type above

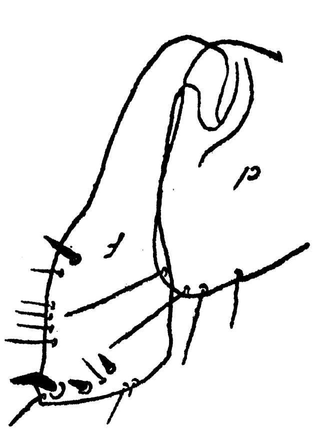


FIG. 63. *Amphipsylla aspalacis*, male. (After Jordan.)

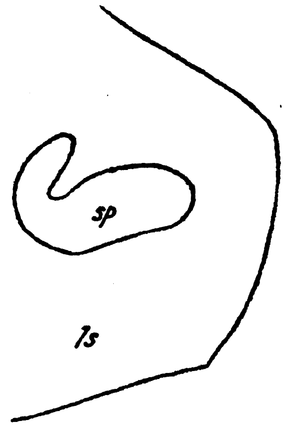


FIG. 64. *Amphipsylla aspalacis*, female. (After Jordan.)

middle of posterior margin; between these two marginal spiniforms five thin marginal bristles; below apical margin an oblique row of three, of which the first and third are spiniform, the middle one being a bristle; a subspiniform bristle on posterior apex. Distal apex of 9*s* with a curved thick bristle.

Female.—Apex of 7*s* rounded-convex. 8*t* with one long bristle below stigma and two to four small bristles on widened area twenty-three to twenty-six on outside and three or four on inside. Head of spermatheca a little longer than tail, distinctly separated from it.

37. AMPHIPSYLLA CASIS Jordan et Rothschild. 1911. Text figs. 65 and 66.

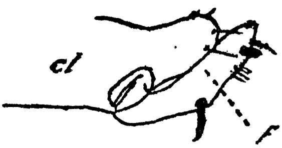


FIG. 65. *Amphipsylla casis*, male. (After Jordan and Rothschild.)

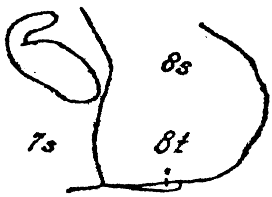


FIG. 66. *Amphipsylla casis*, female. (After Jordan and Rothschild.)

First occipital row composed of one bristle. Metasternum with only one long bristle which is occasionally accompanied by a minute seta. Metepimeron with seven bristles (two, three, two).

Male.—8*s* densely hairy, longest hair longer than 8*s*. Clasper elongate, upper margin distinctly incurved. Manubrium slightly dilated before middle along posterior margin. Finger widest at

middle, narrowing to apex and provided with two spiniforms, one below apex, the other at middle. Apical third of 9*s* very narrow, top more strongly sclerotized and bearing a short, proximally thick, terminal bristle on each side.

Female.—Apex of 7*s* slightly incurved. Head of spermatheca about twice as long as tail.

38. AMPHIPSYLLA MITIS Jordan, 1929. Text figs. 67 and 68.

First occipital row composed of one long bristle. Metepimeron with six or seven bristles (two, three or four, one).

Male.—Clasper somewhat rectangular in outline, posterior margin sinuate. Finger widest at apex; apical margin more

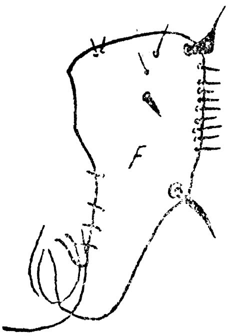


FIG. 67. *Amphipsylla mitis*, male. (After Jordan.)

FIG. 68. *Amphipsylla mitis*, female. (After Jordan.)

or less truncate; upper posteroapical spiniform curved and widest at center; median spiniform of hind margin placed low, about middle; between these two marginal spiniforms a marginal row of eight or nine bristles; one lateral spiniform situated in center of apical portion of finger, above it two bristles of which one is subspiniform.

Female.—Fourth, fifth, and sixth sternites with median vertical incrassation, strongest in fourth. 7*t* with posterior margin slightly incurved, upper angle strongly rounded, portion below antepygidial bristles somewhat dilated. Apex of 7*s* slightly concave. On lower widened area of 8*t* eighteen bristles on outside, two of these apical. Head of spermatheca rather strongly convex dorsally and concave ventrally, little longer than tail.

39. AMPHIPSYLLA VINOGRADOVI Ioff, 1927. Text figs. 69 and 70.

First occipital row with one bristle.

Male.—8*s* bearing eight to ten thick bristles at apex. Clasper elongate, dorsal margin sinuate. Manubrium tapering towards apex. Finger widest at apex which is rounded off, with two submarginal spiniforms near posterior apex; posterior margin divided into three subequal portions by two rather thick bristles; between these two thick bristles five thin bristles. Apex of 9*s* widening toward end and bearing four bristles.

Female.—Apex of 7*s* with a distinct small notch below middle.

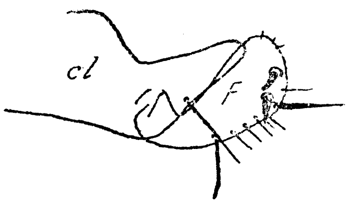


FIG. 69. *Amphipsylla vinogradovi*, male. (After Ioff.)

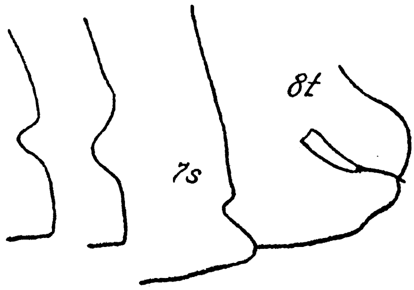


FIG. 70. *Amphipsylla vinogradovi*, female, variations of seventh sternite. (After Ioff.)

Subfamily CTENOPHTHALMINÆ Rothschild, 1915

Head with genal comb which is horizontal and composed of three nearly equal spines. Eyes rudimentary. Antennal groove closed, at least in female. Three antepygidial bristles in both sexes. Only one genus of this family known from China.

13. Genus CTENOPHTHALMUS Kolenati, 1857

Frontal tubercle present. Eyes feebly developed, almost unpigmented. Genal comb composed of three spines. Labial palpus 5-jointed, last joint with a sickle-shaped apical bristle. Frontal row complete. Ocular row consisting of three bristles. Antennal groove closed, especially in female. First occipital row composed of two separated parts in male, second row represented by one bristle. Fifth hind tarsal segment with three pairs of lateral plantar bristles and a proximal pair on ventral surface in between first lateral pair. Hind coxa without patch of spinelets on inner side. Three antepygidial bristles in both sexes. Finger with small sensory cones in male.

Key to the species of Ctenophthalmus.

1. Sixth and seventh abdominal tergites with one row of bristles. Process of clasper divided by a sinus into a broad, round, anterior portion and

a narrow, conical, posterior portion. Apex of finger not distinctly sinuate .... *C. yunnanus* Jordan.
Sixth and seventh abdominal tergites with two rows of bristles............ 2.
2. 7s of female more or less incurved twice, sinus shallow, lobes short, central lobe situated below middle of apex. Stylet more than three times as long as wide at base. Incrassation not well defined. Stigma of 8*t* smaller.. *C. parcus* Jordan.
7s of female distinctly incurved twice, sinus deeper, lobes longer, central lobe situated at middle of apex. Stylet less than three times as long as wide at base. Incrassation well defined, upper portion nearly parallel with upper sinus. Stigma of 8*t* larger.... *C. dinormus* Jordan.

40. CTENOPHTHALMUS PARCUS Jordan, 1932. Text figs. 71 and 72.

Front strongly rounded, tubercle a little below middle. Labial palpus reaching to four-fifths of fore coxa. Pronotal comb of eighteen to twenty spines which are at least as long as pronotum, usually longer. Hind tibia with seven dorsal notches. Stigma of 8*t* small.

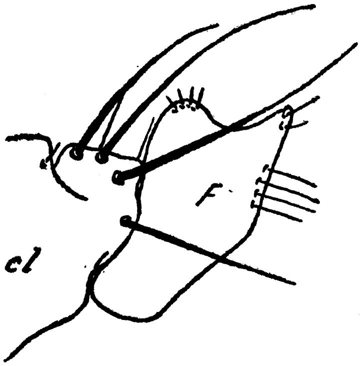


FIG. 71. *Ctenophthalmus parcus*, male. (After Jordan.)

Male.—Process of clasper short and broad, with four or five long bristles, apex more or less truncate, slightly wavy. Manubrium short and hooked at apex. Finger broadest at apex which is deeply sinuate and divided into a rounded anterior lobe with four spiniform

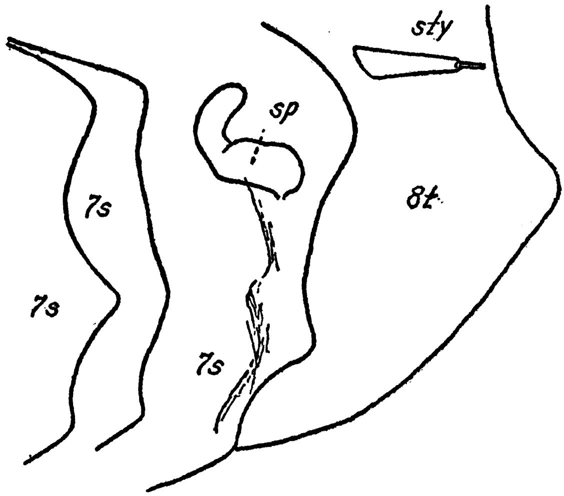


FIG. 72. *Ctenophthalmus parcus*, female, variations of seventh sternite. (After Jordan.)

bristles and a conical posterior lobe. Apex of posterior arm of 9*s* about two and one-half times as long as broad, gradually rounded from upper angle ventrad, with about fifteen thin bristles.

Female.—Apex of 7*s* with an upper sinus and a lower sinus, both shallow, lobes short, upper lobe broader than lower; marginal area incrassate. Stylet elongate-conical, slender, a little more than thrice as long as broad.

41. CTENOPHTHALMUS YUNNANUS Jordan, 1932. Text fig. 73.

Closely allied to *C. parcus*. Process of clasper differing in having a sinus which divides it into a rounded anterior lobe and a conical posterior lobe. Finger slender, apex slightly incurved. Apex of anterior arm subtruncate, that of posterior arm more truncate.

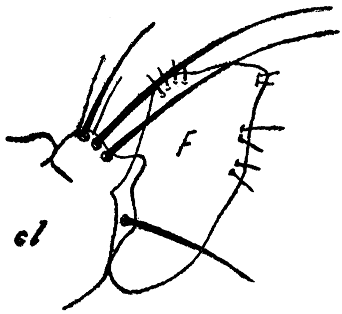


FIG. 73. *Ctenophthalmus yunnanus*, male. (After Jordan.)

42. CTENOPHTHALMUS DINORMUS Jordan, 1932. Text fig. 74.

Female.—Near *C. parcus*. Apex of 7*s* incurved twice as in *C. parcus*, sinus deeper, lobes therefore longer; internal incrassation with a well-defined frontal margin, which above middle lobe is parallel with the apical margin of 7*s* and below upper lobe forms a narrow, gently curved, posteriorly pointed ridge. Stigma of 8*t* larger. Stylet much shorter.

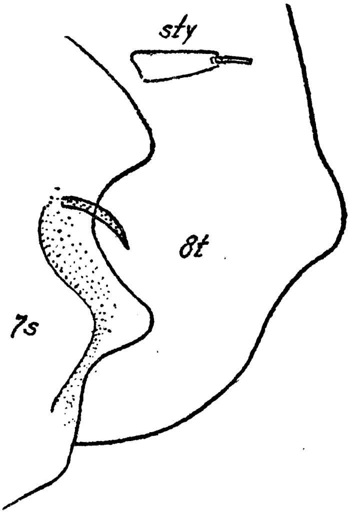


FIG. 74. *Ctenophthalmus dinormus*, female. (After Jordan.)

Subfamily RHADINOPSYLLINÆ Wagner, 1930

Head with genal comb, which is obliquely vertical, composed of four to six spines. Eye rudimentary. Antennal groove closed, at least in female. Antepygidial bristles present in female, lacking in male.

Key to the genera of Rhadinopsyllinæ.

1. Ocular bristle present. Dorsal margins of abdominal tergites and ventral margins of abdominal sternites not sclerotized. 7*t* of female with two, seldom three, antepygidial bristles, and without a process. *Rectofrontia* Wagner et Argyropulo.
   Ocular bristle absent. Dorsal margins of abdominal tergites and ventral margins of abdominal sternites strongly sclerotized. 7*t* of female with a process bearing two spines between two groups of three antepygidial bristles .... *Stenischia* Jordan.

14. Genus STENISCHIA Jordan, 1932

Female.—All spines of genal comb on genal margin, none at margin of antennal groove. Ocular bristle lacking. Eye vestigial. Metepisternum fused with metanotum. Both meso- and metasterna with ventral projection. Dorsal and ventral margins of abdomen strongly sclerotized from base to row of long bristles. 7*t* between two groups of three antepygidial bristles with a process bearing two spines. Coxæ and femora reduced in width.

48. STENISCHIA MIRABILIS Jordan, 1932. Text fig. 75.

Female.—Frontal tubercle prominent. A genal comb of five unequal spines, all of which are situated on genal margin and none at margin of antennal groove. Eye present as a short sulcus below margin of antennal groove. Pronotum with a comb of sixteen spines and a row of ten bristles. Mesonotum incrassate at anterior and dorsal margins. Apical spines on metanotum absent. Fore coxa nearly thrice and mid- and hind coxæ more than twice as long as wide at broadest point. Femora reduced in width. Longest apical bristle of fifth hind tarsal segment reaching to basal third of fourth. All fifth tarsi with four pairs of plantar bristles. 7*s* triangular, posterior margin slanting to near ventral angle, which is obliquely truncate-emarginate. 7*t* with a sharp angle below

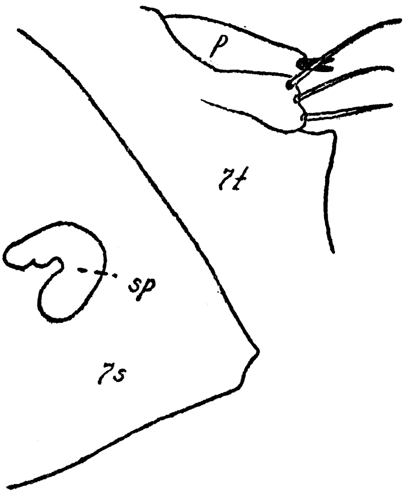


FIG. 75. *Stenischia mirabilis*, female. (After Jordan.)

antepygidial bristles. 8*t* without bristles above or below large stigma, on ventroapical area a patch of nine bristles, nearly all short, on inside three bristles. Stylet nearly cylindrical. Spermatheca of the *Rhadinopsylla* type, apex of tail concave on posterior side, below this groove a swelling.

15. Genus RECTOFRONTIA Wagner et Argyropulo, 1934

Front with or without tubercle. A complete frontal row. Genal comb consisting of four to eight spines, five most common. Labial palpus, as a rule, 5-jointed, sometimes up to 8-jointed. Eye vestigial. Ocular row composed of two bristles. Two complete occipital rows besides apical row. Last tarsal segments usually with four pairs of lateral plantar bristles. Male without antepygidial bristles; female with two, seldom three, long bristles on each side.

Key to the species of Rectofrontia.

1. Labial palpus 6- to 8-jointed........ 2.
   Labial palpus 5-pointed .... 3.
2. Labial palpus 7- or 8-jointed. Genal comb composed of four spines, upper spine shorter than next. Longest apical bristle of first hind tarsal segment reaching beyond third segment. Ventral portion of 7*s* of female not divided by a slit........ *R. jaonis* (Jordan).
   Labial palpus 6-jointed. Genal comb composed of six or seven spines, upper spine equalling next. Longest apical bristle of first hind tarsal segment reaching beyond second segment. Ventral portion of apical margin of 7*s* of female divided by a deep narrow slit.
   R. insolita (Jordan).
3. Genal comb composed of seven or eight spines, dorsal spine shorter than ventral. Pronotal comb composed of twenty-six to twenty-eight spines. 9*s* of male widest at apex........ *R. dives* (Jordan).
   Genal comb usually with five spines, dorsal spine longer than ventral. Pronotal comb usually composed of less than twenty-five spines. 9*s* of male not widest at apex........ 4.
4. Posterior arm of 9*s* of male always broader than anterior arm. Longest apical bristle of second hind tarsal segment usually not extending beyond fourth segment........ 5.
   Posterior arm of 9*s* of male much narrower than anterior arm. Longest apical bristle of second hind tarsal segment extending beyond fourth segment .... *R. tenella* (Jordan).
5. Apex of 8*s* of male incurved or concave........ 6.
   Apex of 8*s* of male convex........ *R. accola* (Wagner).
6. Fifth tarsi of all legs with four pairs of lateral plantar bristles. Apex of 9*s* of male much rounded........ *R. dahurica* (Jordan et Rothschild).
   Fifth tarsi of all legs with five pairs of lateral plantar bristles. Apex of 9*s* of male more pointed........ *R. vicina* (Wagner).

44. RECTOFRONTIA DAHURICA (Jordan et Rothschild, 1923). Text fig. 76.

Frontal tubercle present. Genal comb composed of five spines, ventral spine nearly one-fourth shorter than dorsal, dorsal spine one-fifth shorter than subdorsal, which is longest. Pronotal comb composed of nineteen to twenty-one spines. Second hind tarsal segment with one long apical bristle reaching beyond fourth.

Male.—8*t* without bristles below stigma; 8*s* with a ventro-apical row of seven to nine long bristles. Process of clasper conical. Manubrium strongly curved, proximally broad and abruptly slender at apex. Finger slender, tapering towards apex, reaching apex of clasper or a little beyond, anterior margin smooth. Posterior arm of 9*s* sole-shaped, widest above middle, much wider than anterior arm.

Female.—Tail of spermatheca not carved in.

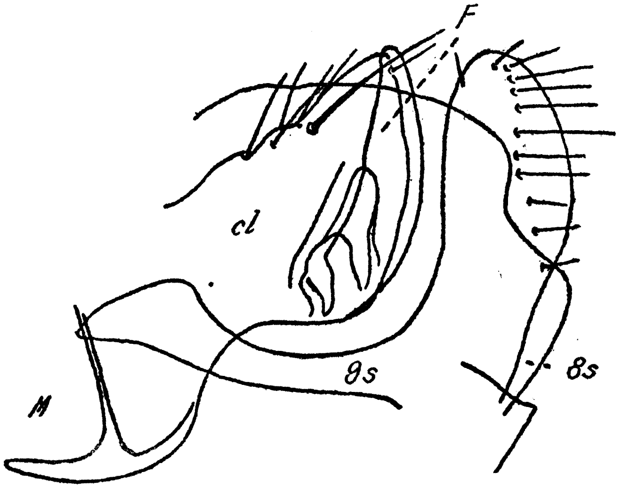


FIG. 76. *Rectofrontia dahurica*, male. (After Jordan and Rothschild.)

45. RECTOFRONTIA TENELLA (Jordan, 1929). Text figs. 77 and 78.

Frontal tubercle prominent. Genal comb with five spines, upper spine much broader and much more dorsal than ventral spine. Labial palpus 5-jointed. Pronotal comb composed of sixteen or seventeen spines. Longest apical bristle of second hind tarsal segment extending beyond apex of fourth.

Male.—8*s* with a row of three bristles on each side. Manubrium not strongly widened towards base. Clasper dorso-apically rounded and incurved, not conical, strongly ventricose on ventral margin. Finger strongly curved in basal half, widest near base and tapering gradually towards apex. Posterior arm

of 9*s* of similar width with finger, much narrower than anterior arm and tapering towards apex.

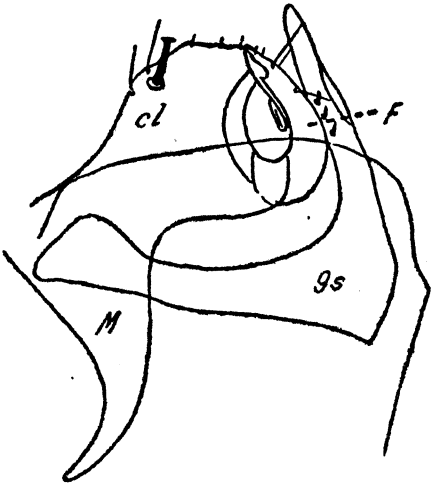


FIG. 77. *Rectofrontia tenella*, male. (After Jordan.)

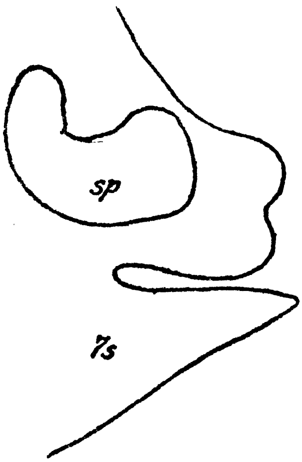


FIG. 78. *Rectofrontia tenella*, female. (After Jordan.)

Female.—Apex of 7*s* without sinus, very broad and rounded. Tail of spermatheca caved in on posterior side, bearing a projection below cavity. A small species, less than two millimeters long.

46. RECTOFRONTIA DIVES (Jordan, 1929). Text figs. 79 and 80.

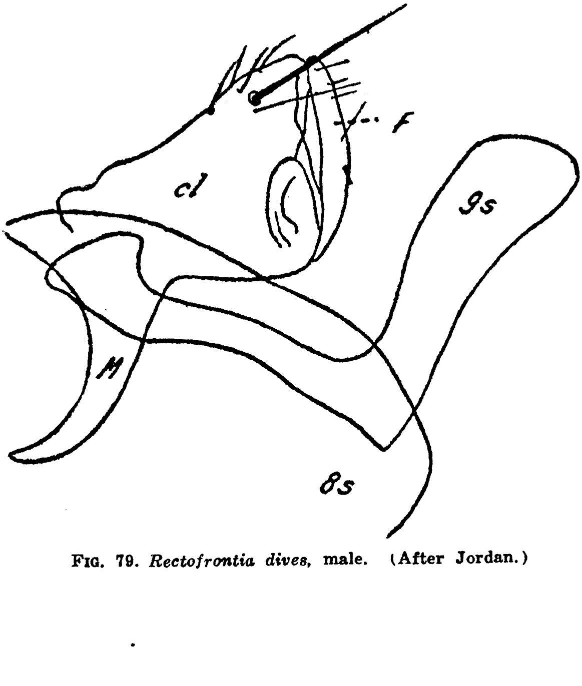


FIG. 79. *Rectofrontia dives*, male. (After Jordan.)

Genal comb composed of seven or eight spines, dorsal spine shorter than rest. Frontal tubercle central in position. Labial palpus 5-jointed. Pronotal comb composed of twenty-six to twenty-eight spines. Fifth segment of all tarsi with five pairs of plantar bristles.

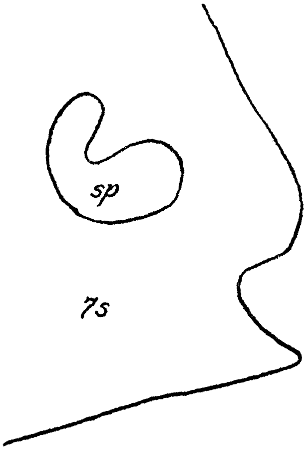


FIG. 80. *Rectofrontia dives*, female. (After Jordan.)

Male.—8*t* with some bristles above stigma. Clasper with one long dorsal bristle and many small bristles, lower margin strongly ventricose. Finger very slender, widest at middle and reaching apex of process of clasper, anterior margin smooth. Proximal dilation of anterior arm of 9*s* angulate on anterior and posterior sides, posterior arm widest at apex, anterior arm narrower than posterior arm.

Female.—Apex of 7*s* divided by a broad, rounded subventral sinus into a broad, round upper lobe and a conical lower lobe. 8*t* with eight or nine spiniform bristles at and close to apical margin. Spermatheca with subcylindrical tail.

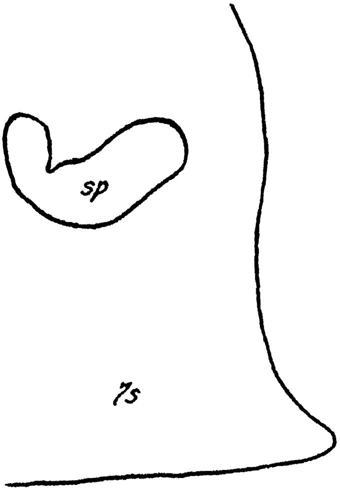


FIG. 81. *Rectofrontia jaonis*, female. (After Jordan.)

47. RECTOFRONTIA JAONIS (Jordan, 1929). Text fig. 81.

Female.—Frontal tubercle small, nearer to oral angle. Labial palpus secondarily divided into seven or eight segments, divisions not quite complete. Genal comb composed of four spines, upper spine shortest. Longest apical bristle of first hind tarsal segment reaching beyond third segment. Apical margin of 7*s* strongly slanting, slightly and broadly incurved so as to form a rounded ventral lobe.

48. RECTOFRONTIA INSOLITA (Jordan, 1929). Text figs. 82 and 83.

Frontal tubercle prominent. Genal comb composed of seven spines, rarely six. Labial palpus 6-jointed, reaching beyond apex of fore coxa. Pronotal comb composed of about twenty-

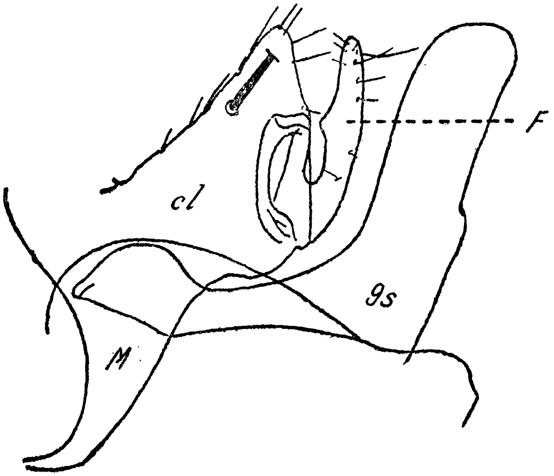


FIG. 82. *Rectofrontia insolita*, male. (After Jordan.)

five spines. Longest apical bristle of second hind tarsal segment reaching beyond fourth.

Male.—Clasper with a long subdorsal bristle. Manubrium strongly broadened towards clasper. Finger with a sharp process at middle of anterior margin. Posterior margin of proximal dilation of anterior arm of 9*s* rounded, not distinctly angulate; posterior arm wider than anterior arm, of nearly even width and with two subdorsal rows of spiniforms.

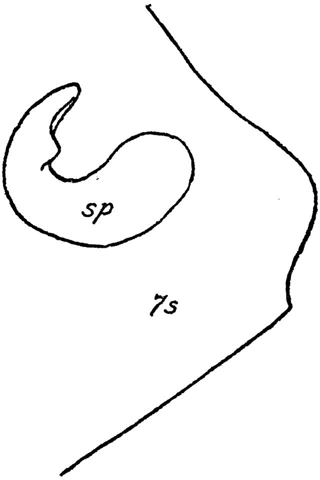


FIG. 83. *Rectofrontia insolita*, female. (After Jordan.)

Female.—Upper apical margin of 7*s* strongly slanting dorsally; lower portion with a deep narrow bay, lobe above bay sinuate near middle, thus divided into two round sublobes, lobe below bay conical. 8*t* with one bristle above stigma, a row of four to five bristles below stigma.

49. RECTOFRONTIA ACCOLA (Wagner, 1929). Text fig. 84.

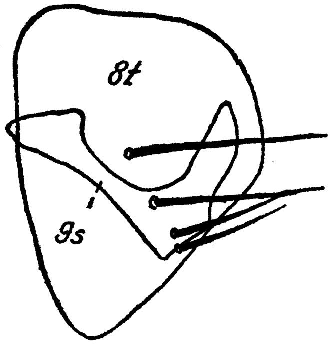


FIG. 84. *Rectofrontia accola*, male. (After Wagner.)

Male.—Dorsal spine of genal comb longer than ventral spine, with end reaching to three-fourths length of subdorsal spine. Ocular bristle not accompanied by any other bristles. Middle abdominal sternites with two bristles on each side. 8*s* with apical margin rounded off, without a side projection and with a row of one to four long bristles. Manubrium very short, wide at base. Posterior arm of 9*s* with an incurving along posterior margin, thumblike in outline.

50. RECTOFRONTIA VICINA (Wagner, 1929). Text fig. 85.

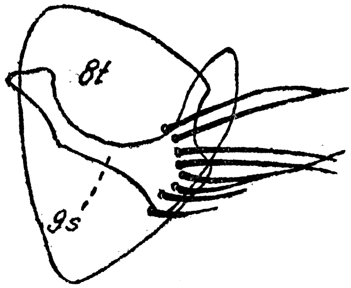


FIG. 85. *Rectofrontia vicina*, male. (After Wagner.)

Male.—Dorsal spine of genal comb somewhat longer than ventral spine, attaining two-thirds length of subdorsal spine. Middle abdominal sternites with three bristles on each side. 7*s* with eight stout bristles in an arched row near apex. Posterior arm of 9*s* much broader than anterior arm which is angulate at middle.

2. Family CTENOPSYLLIDÆ Baker, 1905

Head usually with genal comb. Eyes present or absent. Vertical suture between bases of antennal grooves distinctly present. Thoracic segments not strongly shortened, their tergites together longer than first abdominal segment. Pronotal comb often present. Abdomen often with combs and heavily clothed with bristles. Antepygidial bristles, as a rule, present. Male, clasper with one movable finger. Female, abdomen of gravid female only slightly distended, provided in a number of genera with two seminal receptacles.

Some members of this family are very large.

Key to the subfamilies of Ctenopsyllidæ.

1. Genal comb composed usually of three or more spines, none of them overlapping .... CTENOPSYLLINÆ.
   Genal comb composed of two spines, one of which overlaps the other. NEOPSYLLINÆ.

Subfamily CTENOPSYLLINÆ Wagner, 1927

Genal comb consisting of three or more spines, none of them overlapping. Abdomen of female with one seminal receptacle.

Key to the genera of Ctenopsyllinæ.

1. Labial palpus consisting of one or two segments, not extending much beyond apex of maxilla........................ *Stenoponia* Jordan et Rothschild.
   Labial palpus consisting of five segments, extending much beyond apex of maxilla .... 2.
2. Frontal spiniform absent. Genal comb composed of three or more flattened leaflike spines.. *Palæopsylla* Wagner.
   Frontal spiniform present. Genal comb composed of ordinary spines.... 3.
3. Position of eye normal. Genal comb composed of four or less spines. *Ctenopsyllus* Kolenati.
   Position of eye near top of front. Genal comb composed of fifteen spines. *Pectinoctenus* Wagner.

16. Genus STENOPONIA Jordan et Rothschild, 1911

Labial palpus 1- or 2-segmented, not extending much beyond apex of maxilla. Genal process narrow and short, not reaching further backwards than uppermost spine of genal comb. Club of antenna short in both sexes. First pair of plantar bristles of fifth tarsal segment placed in between second pair. Female with only one spermatheca.

51. STENOPONIA CŒLESTIS Jordan et Rothschild, 1911. Text figs. 86 and 87.

Female.—Genal composed of nine spines. Labial palpus 1-segmented. Pronotal comb composed of thirty-five spines. Ab-

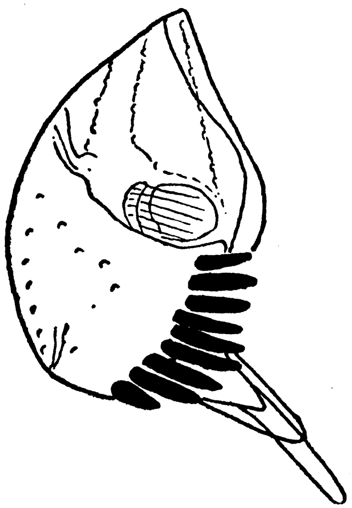


FIG. 86. *Stenoponia cœlestis*, female, head. (After Jordan and Rothschild.)

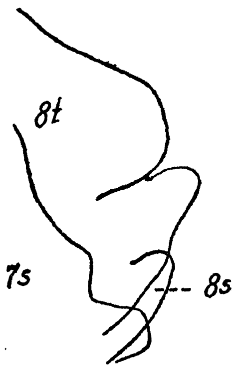


FIG. 87. *Stenoponia cœlestis*, female (After Jordan and Rothschild.)

dominal tergites with only two rows of bristles each, only first, second, and third segments having an incomplete third row. Comb of 1*t* consisting of thirty-one spines on two sides together. Four antepygidial bristles on each side. Apex of 7*s* divided by a rather deep sinus.

8*t* divided by an apical incision into a broad, setose upper lobe and a narrow, naked lower lobe. A large species, 3.5 millimeters long.

17. Genus PALÆOPSYLLA Wagner, 1902

Frontal tubercle prominent. One frontal row. Eye vestigial. Vertical genal comb composed of four flattened spines, dorsal spine short and triangular, second from above long, much pointed. Labial palpus 5-segmented. Two occipital rows present. Inner side of hind coxa without spinelets. Fifth tarsal segment with first pair of plantar bristles situated between second pair. Some abdominal segments with short apical teeth. Three antepygidial bristles.

Male.—8*s* very broad. Process of clasper not marked.

52. PALÆOPSYLLA REMOTA Jordan, 1929. Text fig. 88.

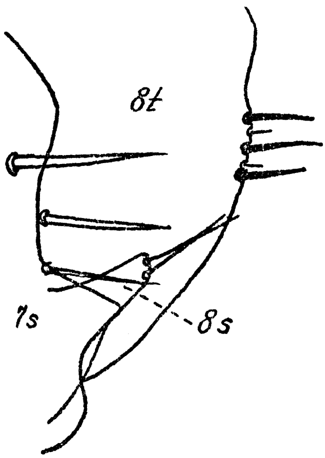


FIG. 88. *Palæopsylla remota*, female. (After Jordan.)

Female.—Dark portion of short upper genal spine narrower, second spine broader than in other species of this genus, third spine pointed. Labial palpus reaching to apex of fore coxa. Pronotal comb composed of fifteen long, narrow spines. Apex of 7*s* with a broad upper lobe and a triangular subventral lobe, latter projecting more than former. 8*t* with a vertical row of three bristles on ventral middle portion; apical margin shallowly sinuate, with three bristles below sinus exclusive of two small ones between them. Apex of 8*s* conical, with long apical bristles.

18. Genus CTENOPSYLLUS Kolenati, 1863

Head strongly angulated. Front with two or more spiniforms near frontal tubercle. Vertical genal comb composed of two to four, seldom six, spines. Eye feebly developed, almost un-

pigmented. Ocular row composed of two bristles. Three occipital rows. Hind tibia with a row of numerous short, equal bristles forming a comb. Fifth tarsal segment with first pair of plantar bristles situated between second pair. Antepygidial bristles, three in male and four or five in female. 8s well developed in male.

53. CTENOPSYLLUS SEGNIS (Schönherr, 1811). Text figs. 89 and 90.

Four genal spines forming a vertical row. Many frontal bristles of which two are spiniform. Three well-developed occipital rows. Pronotal comb composed of about twenty spines.

Male.—Process of clasper with apex rounded. Finger more than twice as long as broad, almost of even width from base to apex, slightly and nearly evenly curved along posterior margin.

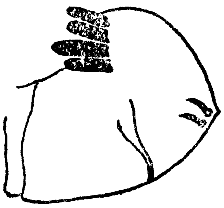


FIG. 89. *Ctenopsyllus segnis*, female, head. (After Rothschild.)

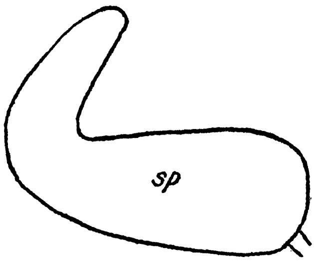


FIG. 90. *Ctenopsyllus segnis*, female, spermatheca. (After Fox.)

Female.—Stylet less than three times as long as basally broad. Head of spermatheca elongate, about one-third longer than tail and about twice as broad at base as at tail.

19. Genus PECTINOCTENUS Wagner, 1929

Differs from *Ctenopsyllus* by the complete development of an antennal comb which runs parallel to the entire anterior margin of the antennal groove, and by the dislocation of the eye towards the top of the head near the base of antennæ, in fact limited by the development of the genal comb.

54. PECTINOCTENUS ADALIS Jordan, 1929. Text fig. 91.

Male.—Genal comb composed of fifteen spines. Pronotal comb composed of thirty-two spines. Besides apical row, three rows of bristles on mesonotum and two on metanotum. Metepimeron with eight (four, three, one) bristles. Abdominal

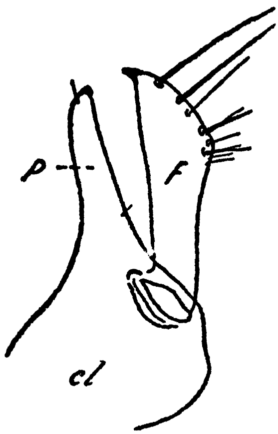


FIG. 91. *Pectinoctenus adalis*, male. (After Jordan.)

tergites with two rows of bristles each. Three antepygidial bristles. 8*t* with eight bristles on widened area below stigma. Process of clasper slender, gradually narrowing. Finger widest above middle, posterior margin rounded from this point to tip, provided with eight bristles, no spiniform present. Apex of process of clasper and finger clawlike, brown, curved toward each other. 9*s* with broad anterior arm and very narrow posterior arm; anterior arm with a narrow, rounded proximal apex, distal half of posterior arm bristly.

Subfamily NEOPSYLLINÆ Oudemans, 1909

Genal comb reduced to two spines, one of which overlaps the other.

20. Genus NEOPSYLLA Wagner, 1902

Frontal tubercle small. Genal comb consisting of two overlapping spines. Front reduced. Hind coxa with or without a patch of spinelets. First pair of plantar bristles of hind legs moved on to ventral surface between second pair, or first pair of plantar bristles of all legs placed ventrally between second pair. Some abdominal segments with dorsal apical teeth.

Key to the species of Neopsylla.

1. Male, process of clasper not divided into two lobes. Female, upper angle of apex of 7*s* not divided into two lobes........ 2.
   Male, process of clasper divided into two lobes. Female, upper angle of apex of 7*s* divided into two lobes........ 5.
2. Pronotum with two rows of bristles in front of pronotal comb. Male, finger with very acuminate apex........ 3.
   Pronotum with one row of bristles in front of pronotal comb. Male, finger without very acuminate apex........ 4.
3. Male, finger with an acuminate apex. Female, apex of 7*s* with an upper long, rounded lobe........ *N. bidentatiformis* (Wagner).
   Male, unknown. Female, apex of 7*s* without this lobe, shallowly sinuate near middle........ *N. compar* Jordan et Rothschild.
4. Occiput with two rows of bristles. Male, finger widest near distal part, evenly rounded along posterior margin. Female, 7*s* with rounded lobe above sinus........ *N. aliena* Jordan et Rothschild.
   Occiput with three rows of bristles. Male, finger widest near proximal portion, slightly concave near middle of posterior margin. Female, 7*s* with triangular or pointed lobe above sinus.... *N. anoma* Rothschild.

5. Male, second lobe of process of clasper very broad and more or less rounded. Posterior margin of finger evenly convex and without spiniform .... 6.

Male, second lobe of process of clasper narrow and distinctly conical. Posterior margin of finger slightly concave near middle and with a spiniform near base.. *N. honora* Jordan.

6. Male, second lobe of process of clasper bearing bristles along anterior half of dorsal margin. Finger robust, about two and one-half to three times as long as wide. Manubrium broad and widest at middle. 8s not triangular and with broad apex............................ *N. specialis* Jordan.

Male, second lobe of process of clasper bearing bristles along posterior half of dorsal margin. Finger slender and about five times as long as wide (near middle). Manubrium slender, widest at base. 8s triangular with sharp apex. Female, upper angle of 7s divided into two pointed lobes.. *N. stevensi* Rothschild.

55. NEOPSYLLA BIDENTATIFORMIS (Wagner, 1893). Text figs. 92 to 94.

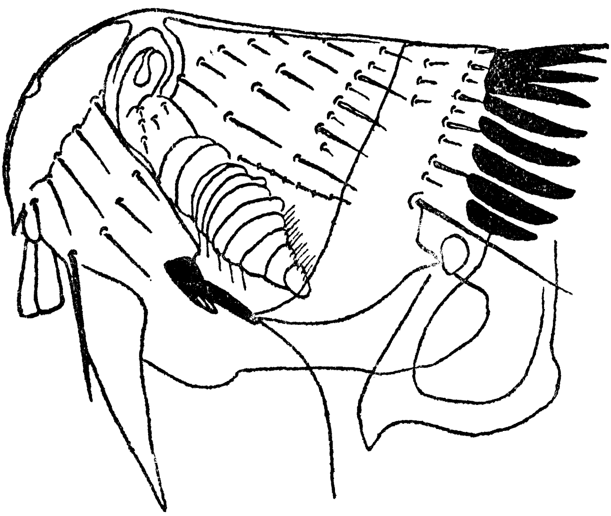


FIG. 92. *Neopsylla bidentatiformis*, male, head. (Author's drawing.)

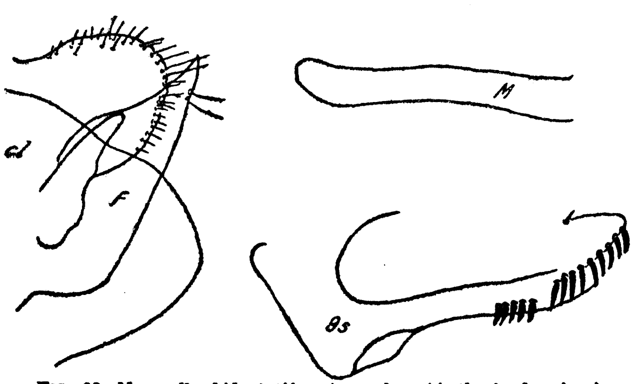


FIG. 93. *Neopsylla bidentatiformis*, male. (Author's drawing.)

28729——6

FIG. 94. *Neopsylla bidentatiformis*, female. (Author's drawing.)

Front perpendicular, with a small frontal tubercle. Eye incompletely pigmented in male. Antennal groove produced partly onto prosternum. Ocular row composed of four bristles and frontal row of five short bristles. Occiput with three rows of bristles. Pronotal comb composed of eighteen spines. Metepimeron with three rows of transverse vertical bristles of which the two front rows are curved.

Male.—Process of clasper very much rounded and hairy. Finger with pointed apex, posterior margin more or less truncate. Posterior arm of 9*s* along apicoventral margin with a row of about fifteen shortened bristles.

Female.—Apex of 7*s* with two rows of stout bristles, slightly sinuate, lobe above sinus projecting, rounded. 8*s* heavily beset with straight bristles projecting backward; marginal row consisting of nine bristles, about fifteen lateral bristles of which at least four are long.

56. NEOPSYLLUS ANOMA Rothschild, 1912. Text figs. 95 and 96.

Front strongly rounded with a small frontal tubercle. Eyes almost absent. Frontal row composed of six to eight bristles, ocular row composed of four bristles. Occiput with three rows.

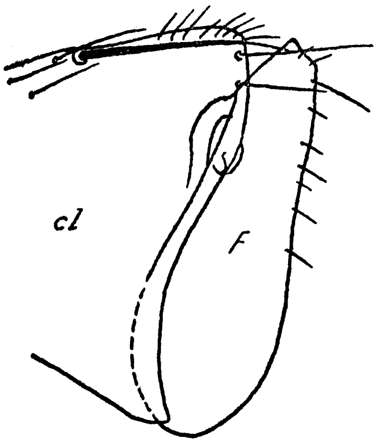


FIG. 95. *Neopsylla anoma*, male. (After Rothschild.)

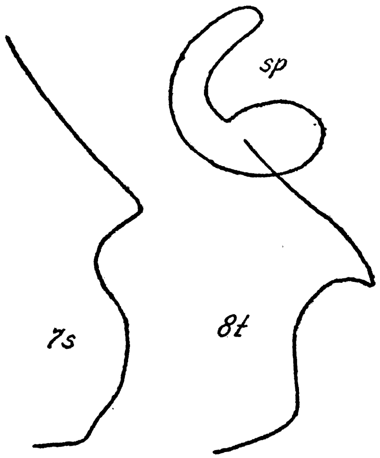


FIG. 96. *Neopsylla anoma*, female. (After Rothschild.)

Pronotal comb composed of eighteen spines. Hind coxa bearing a patch of spinelets on inner side.

Male.—8*t* bearing six short hairs above stigma. 8*s* large, apically truncate-emarginate in lateral view, with angles strongly rounded off. Body of clasper large, upper angle rounded, lower angle acute. Manubrium widest at center. Finger as long as clasper, apex sharp, right-angled. Anterior arm of 9*s* broad, elbowed, proximally rounded, posterior arm narrowest at middle, bearing along ventral margin one long bristle and several smaller bristles.

Female.—Apex of 7*s* with a round sinus, lobe above sinus pointed, lobe below sinus broadly rounded. 8*t* with six short hairs above stigma; no short hairs below, and six or seven long bristles at lower portion; apex sharply pointed. Spermatheca with tail much longer than head.

57. NEOPSYLLA ALIENA Jordan et Rothschild, 1911. Text figs. 97 and 98.

Front vertical in male, more slanting in female. Eye indicated by a narrow oblique bar. Frontal row composed of five to

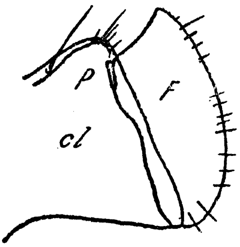


FIG. 97. *Neopsylla aliena*, male. (After Jordan and Rothschild.)

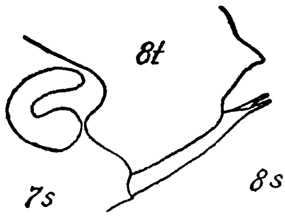


FIG. 98. *Neopsylla aliena*, female. (After Jordan and Rothschild.)

nine bristles, ocular row of three bristles. Pronotal comb composed of sixteen spines. Metepimeron with twelve to fourteen (four to six, five, two or three) bristles. Hind coxa with a patch of spinelets on inner surface. All five pairs of plantar bristles lateral in position.

Male.—8*s* broad, apex almost evenly rounded in side view. Body of clasper almost square, without acetabular bristles. Manubrium widest at center. Posterior margin of finger evenly rounded, bearing a number of small bristles. 9*s* with a somewhat cylindrical and broad anterior arm; posterior arm broad proximally, narrowing towards apex, bearing seven pairs of bristles.

Female.—7*s* divided by a central sinus into a rounded upper lobe and a broader, less rounded lower lobe. Upper apical angle of 8*t* pointed. 8*s* bearing no bristles and ending on each side in a long slender point. Tail of spermatheca about twice as long as head.

58. NEOPSYLLA COMPAR Jordan et Rothschild, 1911. Text fig. 99.

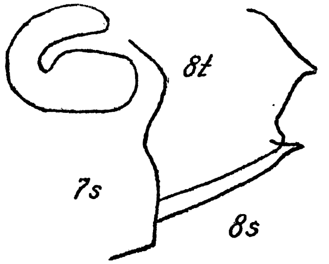


FIG. 99. *Neopsylla compar*, female. (After Jordan and Rothschild.)

Female.—Closely allied to *N. bidentatiformis.* Pronotum bearing a row of eight small bristles in front of postmedial row of bristles on two sides together. Hind coxa with a patch of spinelets. Dorsal bristles of hind tibia thinner. Apex of 7*s* shallowly sinuate. 8*t* bearing a marginal row of six or seven bristles, near these bristles about eight more, of which two are long.

59. NEOPSYLLA STEVENSI Rothschild, 1915. Text figs. 100 and 101.

Male.—Near *N. anoma.* 8*s* broadly conical at apex, bearing about fifteen stout bristles. First process (P_1) of clasper long,

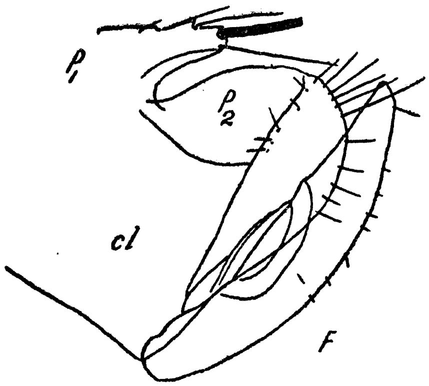


FIG. 100. *Neopsylla stevensi*, male. (After Rothschild.)

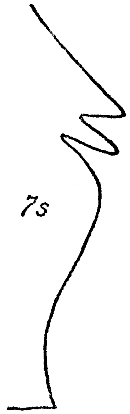


FIG. 101. *Neopsylla stevensi*, female. (After Rothschild.)

with two or three long bristles at apex and some short bristles at dorsal margin, no bristle at ventral margin; second process very broad, distinctly rounded. Manubrium slender, gradually tapering towards apex. Finger very long, evenly rounded at posterior margin. Apical portion of posterior arm of 9*s* bearing about twenty-two shortened bristles.

Female.—Apex of 7*s* very peculiar, upper angle divided into two small pointed lobes.

60. NEOPSYLLA SPECIALIS Jordan, 1932. Text fig. 102.

Male.—Near *N. stevensi,* but differing in genitalia. 8*s* rounded at apex, bearing dozen bristles of which two subapical ones are longest. First process of clasper slightly shorter; second process divided apically into an anterior bristled lobe and a pale rounded lobe. Manubrium very broad, widest at middle. Finger somewhat spindle-shaped, about two and one-half times as long as broad, posterior margin evenly rounded from base to apex. Acetabulum extending much farther dorsad than in *N. stevensi.* Anterior arm of 9*s* broad, somewhat cylindrical; posterior arm narrowing at apical third, apex with a ventral row of six shortened bristles.

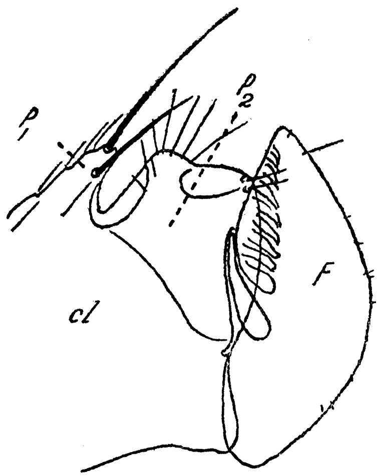


FIG. 102. *Neopsylla specialis,* male. (After Jordan.)

61. NEOPSYLLA HONORA Jordan, 1932. Text fig. 103.

Male.—Near *N. stevensi.* 8*s* with four long subapical bristles. First process of clasper much shorter than those of *N. stevensi* and *N. specialis;* second process conical, with four bristles at apex. Manubrium of clasper narrowing very gradually from base to apex, which is turned up at tip. Finger rectangular, with posterior margin incurved at middle, and a spiniform at posteroventral angle. Anterior arm of 9*s* unusually broad and short; posterior arm narrowing to a point, bearing only thin bristles.

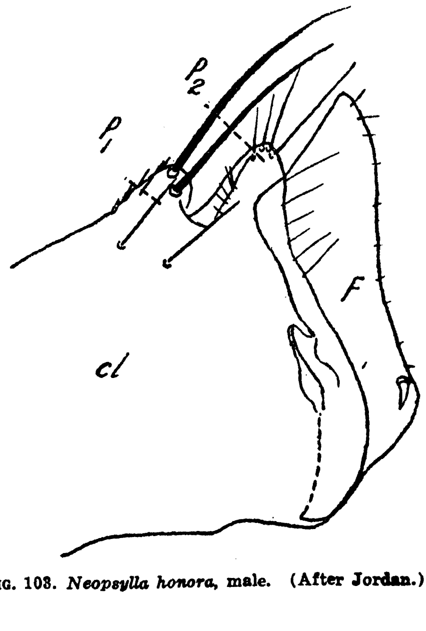


FIG. 103. *Neopsylla honora,* male. (After Jordan.)

3. Family ISCHNOPSYLLIDÆ Wahlgren, 1907

Head without genal comb, but with two preoral flaps at anteroventral portion on each side. Eyes usually greatly reduced or absent. Vertical suture between bases of antennal grooves distinctly present. Thoracic segments not strongly shortened, their tergites together longer than first abdominal tergite. Pronotal comb often present. Abdomen with or without true combs made up of subequal toothlike spines, or false combs made up of enlarged setæ of a transverse row; abdomen with two rows of setæ to each typical tergite, and with tiny apical teeth on some tergites. Antepygidial bristles present or absent. Clasper of male with one movable finger. Abdomen of gravid female only slightly distended, provided with only one seminal receptacle. The members of this family are confined entirely to bats.

Key to the genera of Ischnopsyllidæ.

1. Maxilla sharp and pointed. Antepygidial bristles absent, instead of which there is a false comb on 7t................ *Nycteridopsylla* Oudemans.
   Maxilla truncate. Antepygidial bristles present.. 2.
2. Abdomen with false combs formed by thickening of some bristles in one of transverse rows. Abdominal segments with a transverse dorsal incrassation .... *Myodopsylla* Jordan et Rothschild.
   Abdomen with true combs of subequal toothlike spines. *Ischnopsyllus* Westwood.

21. Genus ISCHNOPSYLLUS Westwood, 1833

Maxilla truncate at apex. Ocular bristle near anterior margin of antennal groove. Two or three rudimentary occipital rows. Six to eight true combs of subequal toothlike spines on thorax and abdomen. Antepygidial bristles present. Male, two acetabular bristles. Female, ductus seminalis with dilated portion.

Key to the species of Ischnopsyllus.

1. Mesonotum with a group of six very long dorsoapical bristles. Male, 8s arm-and-fist-shaped, without bladelike bristles. Finger widest at base and apex. Female, apex of 7s slanting. Tail of spermatheca much longer than head.. *I. comans* Jordan et Rothschild.
   Mesonotum without a group of long dorsoapical bristles. Male, 8s of different shape, with bladelike bristles. Finger widest either at apex or at base. Female, apex of 7s rounded-dilated at middle. Tail of spermatheca shorter than head.. 2.
2. Male, apex of 8s club-shaped, with one bladelike bristle. Process of clasper short and rounded. Female, stylet conical. Head of spermatheca subglobose, about two and one-half times as broad as tail. *I. tateishii* Sugimoto.

Male, apex of 8s not club-shaped, and with five long, bladelike bristles. Upper process of clasper long, conical. Female, stylet more or less cylindrical. Head globose, about two times as broad as tail.

I. needhamia Hsü.

62. ISCHNOPSYLLUS COMANS Jordan et Rothschild, 1921. Text figs. 104 to 106.

Mesonotum with a group of six very long dorsoapical bristles.

Male.—*8t* irregularly square, upper posterior margin slightly incurved, with ten bristles. *8s* narrowest in middle, slightly

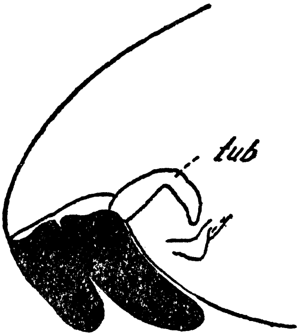


FIG. 104. *Ischnopsyllus comans*, male, head. (After Jordan and Rothschild.)

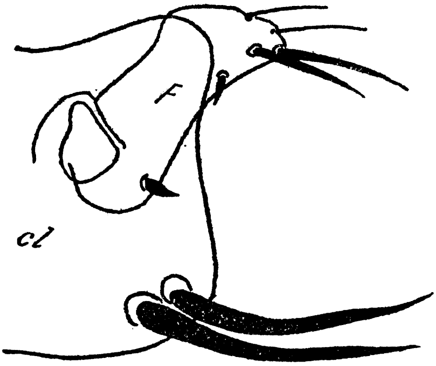


FIG. 105. *Ischnopsyllus comans*, male. (After Jordan and Rothschild.)

widening distally, with apex curved upwards and bearing three long apical bristles. Clasper also irregularly square, distal margin moderately incurved, both upper and lower angles rounded, upper angle produced as a broad rounded lobe, lower angle bearing two very large spiniform bristles. Finger about twice as long as broad, with both anterior and posterior margins incurved and bearing two spiniforms situated farther apart along posterior margin, and, in addition, four apical bristles. *9s* divided by a deep ventral sinus into two lobes; proximal lobe broad, ventrally rounded-dilated, tapering towards apex; apical lobe narrow, widest at middle, bearing five thin bristles.

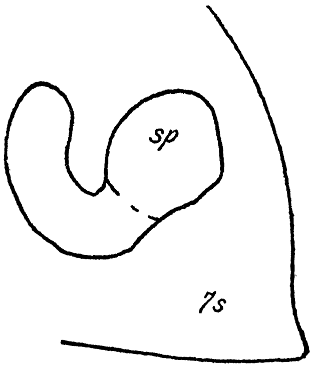


FIG 106. *Ischnopsyllus comans*, female. (After Jordan and Rothschild.)

Female.—*7s* slanting upwards. Stylet short, conical, about two and one-half times as long as broad. Spermatheca with a subglobose head and a long tail.

63. ISCHNOPSYLLUS NEEDHAMIA Hsü, 1935. Text figs. 107 and 108.

Dorsoapical bristles of mesonotum short.

Male.—*8t* irregularly square, posterior margin slightly incurved, bearing seventeen bristles behind stigma. *8s* bearing at apicoventral margin a row of six bristles, proximal to them a group of five very stout, bladelike bristles of which two hind ones are situated on the outer surface, and the three anterior

FIG. 107. *Ischnopsyllus needhamia*, male. (Author's drawing.)

ones on the inner surface. Clasper with a long, projecting upper angle, bearing two weaker spiniform bristles at lower angle. Finger oval, pointing posteriorly, and bearing four short apical bristles and one spiniform at middle of ventral margin.

Female.—Apex of *7s* less rounded-dilated than in *I. tateishii*. Stylet short, cylindrical, about twice as long as broad. Spermatheca with globose head which is not longer than tail.

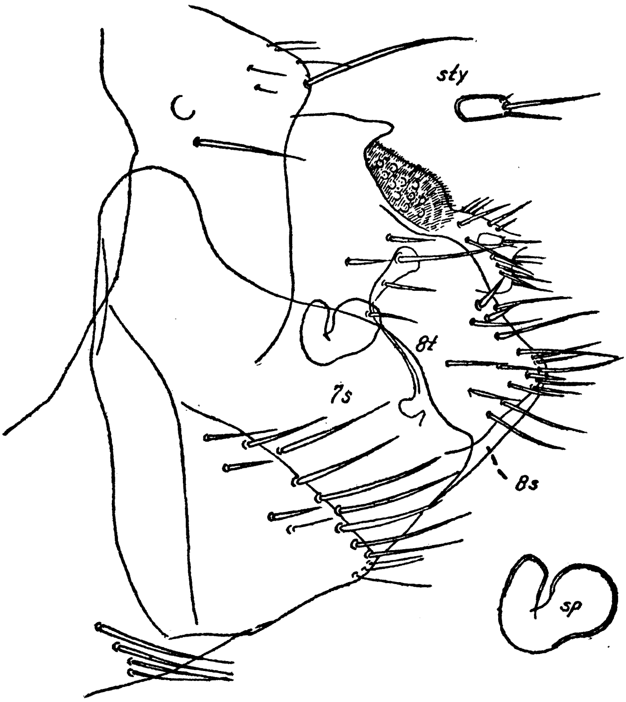


FIG. 108. *Ischnopsyllus needhamia*, female. (Author's drawing.)

64. ISCHNOPSYLLA TATEISHII Sugimoto, 1933. Text figs. 109 and 110.

Dorsoapical bristles of mesonotum short.

Male.—8*t* irregularly square, postericr margin not incurved, bearing ten bristles. 8*s* with club-shaped apex which bears an apical bladelike bristle. Clasper square, distal margin truncate, not incurved, both angles rounded, lower angle bearing two very large spiniform bristles. Finger slender, about four times as long as broad at middle, bearing only one spiniform at middle of posterior margin and, in addition, four short apical bristles. 9*s* also divided into two lobes; proximal lobe ventrally angulate; apical lobe widest at base, bearing two thin bristles.

Female.—Apex of 7*s* rounded-dilated at middle. Stylet slender, conical, about three and one-half to four times as long as broad. Spermatheca with a large subglobose head which is longer than tail.

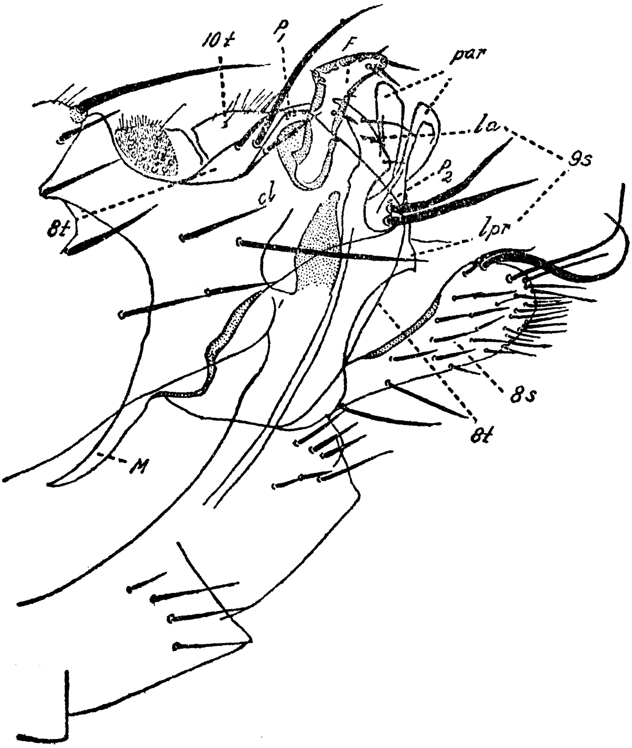


FIG. 109. *Ischnopsyllus tateishii*, male. (Author's drawing.)

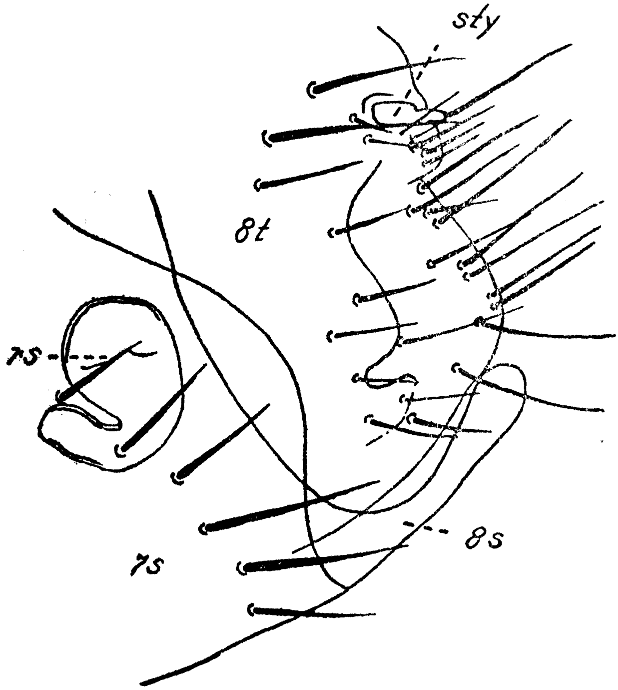


FIG. 110. *Ischnopsyllus tateishii*, female. (Author's drawing.)

22. Genus MYODOPSYLLA Jordan et Rothschild, 1911

Maxilla truncate. Eyes distinct. First segment of maxillary palpus longer than second. Pronotum with a true comb, all other combs composed of thickened bristles of submedian row of tergites. *7t* on each side with a long apical bristle which stands on a conical process of margin. Of all tarsi first pair of plantar bristles of fifth tarsal segment standing between bristles of second pair, third pair displaced ventrally.

65. MYODOPSYLLA TRISELLIS Jordan, 1929. Text figs. 111 and 112.

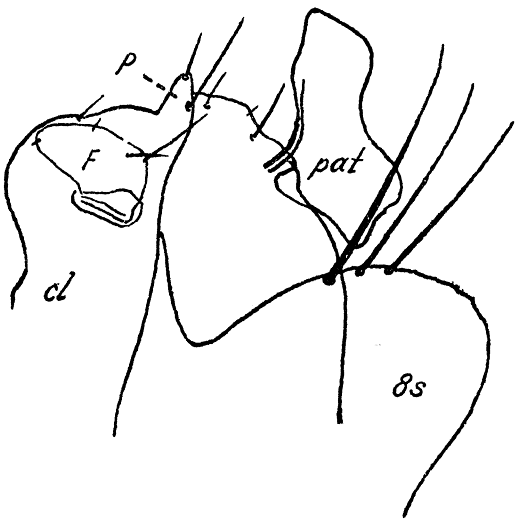


FIG. 111. *Myodopsylla trisellis*, male. (After Jordan.)

Meso-, and metanota with three rows of bristles. First and second abdominal tergites with three rows, others with two. First to third abdominal tergites with a false comb.

Male.—8s with a rounded apical lobe bearing numerous small bristles and three or four stout bristles at dorso-apical margin. Process of clasper conical, bearing two longish bristles. Manubrium very large, longer and basally broader than body of clasper.

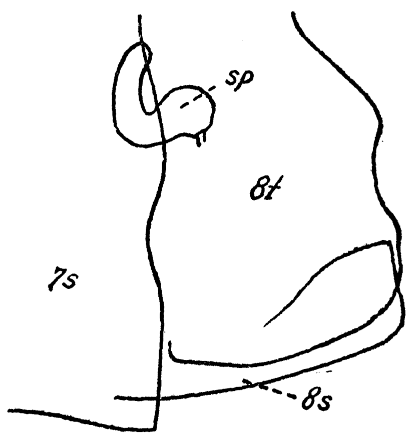


FIG. 112. *Myodopsylla trisellis*, female. (After Jordan.)

Finger short, slightly elbowed, less than twice as long as broad, resembling head of a bird. Paramere somewhat sole-shaped, posterior margin widely sinuate.

Female.—Apex of 7*s* strongly slanting, slightly incurved near middle. Spermatheca with a very long tail.

23. Genus NYCTERIDOPSYLLA Oudemans, 1906

Maxilla acuminate at apex. Ocular bristle absent. Occipital portion prolonged. Two or three rudimentary occipital rows. All species with five combs on thorax and abdomen excluding false comb on 7*t*. Antepygidial bristle absent. Male, one acetabular bristle. Female, ductus seminalis without dilated portion.

66. NYCTERIDOPSYLLA GALBA Dampf, 1910. Text figs. 113 and 114.

Male, front strongly arched. Genal process long, rounded off at apex. Eyes depigmented. Second antennal segment with a long bristle; three long bristles above posterior margin of

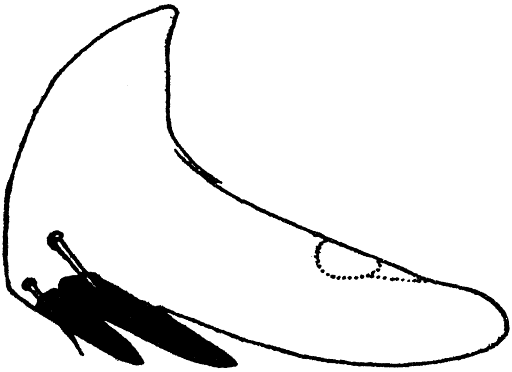


FIG. 113. *Nycteridopsylla galba*, male, part of head. (After Dampf.)

antennal groove. Occiput prolonged. All legs with five pairs of plantar bristles, first pair located between second pair. Altogether five true combs one each on pronotum (twenty-eight to thirty-five spines), metanotum (seven to fourteen spines), 1*t* (eighteen to twenty-four spines), 2*t* (eighteen to twenty-four spines), and 3*t* (sixteen to twenty-four spines). 7*t* with a false comb of ten spines on two sides together. Clasper triangular, with conical process and manubrium. Finger with a rounded lobe at anterodorsal margin, apex provided with two heavy blunt spiniforms, ventral margin with three spiniforms.

Apex of 9*s* widened in form of a knife, terminating in two sharp points.

FIG. 114. *Nycteridopsylla galba*, male. (Author's drawing.)

4. Family VERMIPSYLLIDÆ Wagner, 1889

Head without genal comb. Eyes present. Vertical suture between bases of antennal grooves absent. Preoral flaps lacking. Thoracic segments not strongly shortened, their tergites together longer than first abdominal segment. Pronotal comb lacking. Abdomen without combs, without tiny apical teeth on tergites, but with more than a single row of bristles to each typical abdominal tergite. Antepygidial bristles wanting. Clasper of male with one movable finger. Abdomen of gravid female more or less distended and provided with only one seminal receptacle.

This small family comprises three genera, of which only two are represented in China.

Key to the genera of Vermipsyllidæ.

1. Labial palpus with five, seldom six, segments.......... *Chætopsylla* Kohaut.
   Labial palpus with ten or more segments...... *Vermipsylla* Schimkewitsch.

24. Genus CHÆTOPSYLLA Kohaut, 1903

Combs wanting. Frontal tubercle prominent. Ocular row composed of four bristles, ocular bristle before eye. Labial palpus composed of five, seldom six, segments. Gena often dark, blending with eye. Club of antenna long. One or two occipital rows. Fifth tarsal segment of all legs with four pairs of lateral plantar bristles. Antepygidial bristles wanting in both sexes.

Male.—8s longitudinally divided into two parts. Clasper broad and deep, disclike, without nonmovable process.

Female.—8t longitudinally divided into two parts. Abdomen of gravid female extensible. Usually hairy species.

67. CHÆTOPSYLLA HANGCHOWENSIS sp. nov. Text figs. 115 to 117.

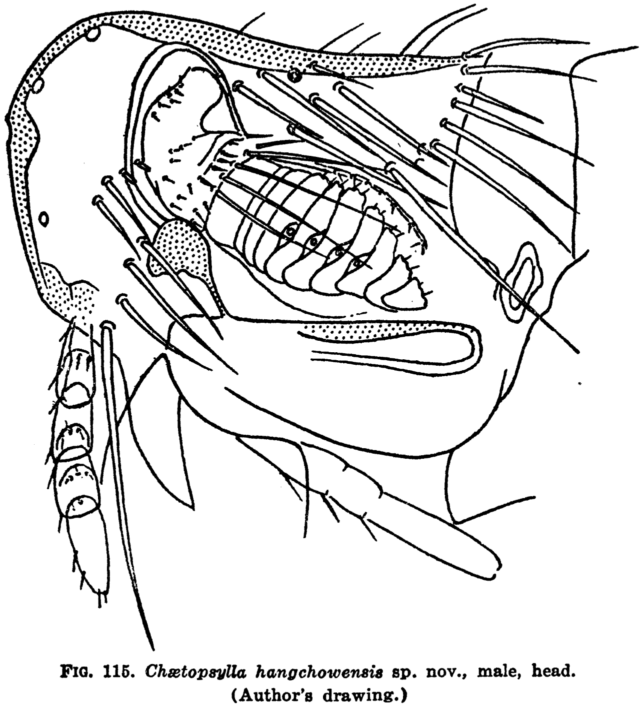


FIG. 115. *Chætopsylla hangchowensis* sp. nov., male, head. (Author's drawing.)

Allied to *C. homœus* Rothschild. Male differing from *homœus* by the finger distinctly tapering towards the apex, apex of manubrium bluntly rounded, posterior margin of clasper provided with fourteen long curved bristles, and shape of paramere

distinctly different. Female differing in that the apex of seventh sternite is rounded-truncate with a slightly incurved central sinus. From *C. mikado* Rothschild, which was known only in the female form, the present species can be distinguished by the longer bristles of the second antennal segment, the presence of three vertical rows of bristles on the epimeron of metathorax, and the thin hairs of the frontal row.

Head.—Head evenly rounded from occiput to mouth in female and slightly concave above occiput in male. Frontal tubercle prominent, situated at middle of frontal margin. Ocular row

FIG. 116. *Chætopsylla hangchowensis* sp. nov., male. (Author's drawing.)

composed of four stout bristles equidistant from each other. Obliquely above eye a frontal row of four (in male) or two to four (in female) small bristles, upper two bristles in male very small, lower two stout, in female all small; this row of small bristles above ocular row in male and somewhat in line with ocular row in female. Eyes distinct. Genal process acute. Bristles of second antennal joint reaching beyond middle of club in male and extending to or a little beyond apex of club in female. Eight (in male, three in female) short setæ present along posterior margin of antennal groove. Maxillary palpus shorter than

labial palpus; proportional lengths of segments of former 19:15:12:26 in female and 17:13:10:20 in male; in male maxillary palpus shorter than lowest bristle of ocular row, in female longer than lowest bristle of ocular row. Labial palpus reaching a little over four-fifths of length of fore coxa; seeming to consist of six or seven segments in male. Apex of maxilla acute. Occiput with a row of three bristles behind base of antenna, one small bristle preceding row and situated on hind

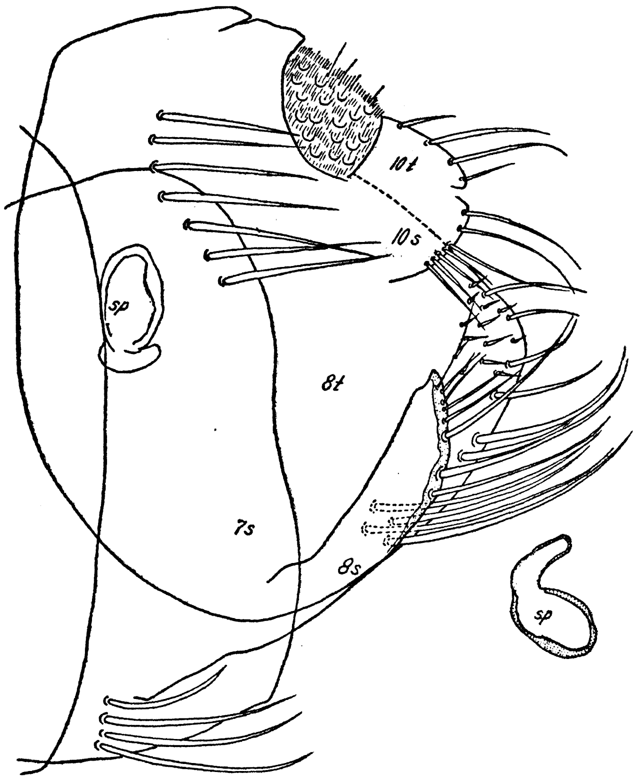


FIG. 117. *Chætopsylla hangchowensis* sp. nov., female. (Author's drawing.)

margin of antennal groove, another row of three larger bristles behind middle of antenna, an apical row of eight (in male) or nine (in female) stout bristles on each side, of which lowest bristle is longest.

Thorax.—Pronotal comb lacking. Pronotum with an apical row of nine bristles on each side (excluding few small hairs between bristles), lowest bristle near spiracle longest. Mesonotum with a submedian row of five to seven bristles and an

apical row of five stout bristles. Mesepisternum with two (in male) or three (in female) bristles. Mesepimeron with four (in male) or five (in female) bristles, lowest bristle near spiracle widely apart and stoutest. Metanotum with a submedian row of six (in male) or eight (in female) strong bristles (excluding smaller ones) and an apical row of six (in male) or five (in female) stout bristles. Metepisternum with two rows of bristles (male, two, four; female, four, five). Metasternum with two rows of stout bristles (two, two). Metepimeron with three rows of bristles, bristles of first row slender, those of second very stout, those of third short and irregular, number of bristles in each row of male six, five or six, five; of female, eight or nine, five or six, seven.

Legs.—Outer surface of fore femur with about fourteen bristles. Hind femur with fourteen (in male) or seventeen (in female) bristles along ventral margin. Hind tibia with six pairs of dorsal spines and with a row of nine (in male) or eleven (in female) bristles on outer surface. Apical bristle of first hind tarsal segment as long as second tarsal segment, apical bristle of second and third hind tarsal segments exceeding apex of following segment. Proportions of tarsal segments of all legs:

		1st.	2d.	3d.	4th.	5th.
Male	Fore tarsi	18	18	17	13	34
	Midtarsi	27	22	18	13	30
	Hind tarsi	47	31	20	14	35
Female	Fore tarsi	20	25	20	16	40
	Midtarsi	40	36	23	17	35
	Hind tarsi	68	44	28	20	55

Abdomen.—Chætotaxy of abdominal segments on each side: *Male.*—1*t*, three rows: two, six, five; 2*t*, two rows: six, nine (one below stigma); 3*t*, two rows: ten (five below stigma), seven (one below stigma); 4*t*, two rows: seven (three below stigma), six; 5*t*, two rows: two (one below stigma), seven (one below stigma); 6*t*, two rows; one (below stigma), five; 7*t*, one row of four.

Female.—1*t*, three rows: two, six, five; 2*t*, two rows: seven, five; 3*t*, two rows: ten (five below stigma), five; 4*t*, two rows: six (two below stigma), five; 5*t*, two rows: two, four; 6*t*, two rows: one, four; 7*t*, two rows: two, three.

Chætotaxy on sternites:

Male.—3*s*, two rows: two, six (all hairs); 4*s*, two rows: two, five (all hairs); 5*s*, one row of five; 6*s*, one row of four; 7*s*, one row of four (stout bristles).

Female.—3*s*, two rows: three, five (all hairs); 4*s*, one row of three; 5*s*, one row of three; 6*s*, one row of two; 7*s*, one row of two. Antepygidial bristles lacking.

Modified segments.—*Male.*—8*t* with one row of eight bristles, lowest two stoutest. Clasper except part connected with manubrium cup-shaped, with a group of nine spinelets near dorsal margin or above finger, another group of sixteen spinelets below finger. Ventroposterior margin of clasper with fourteen stout bristles which are curved at apex, a character which distinguishes this species from all other species of the genus. Manubrium with distal part nearly of even width and with blunt apex. Finger cucumber-shaped, tapering towards apex. Shape of paramere characteristic of the species.

Female.—8*t* bearing on upper half five bristles above stigma and from stigma downwards a regular vertical series of twelve bristles, lower six bristles very stout; apex bearing fourteen bristles (six dorsal and eight ventral), three dorsal bristles and six ventral bristles very stout. On the inner side of apex of 8*t* about thirteen spinelets. 8*s* resembling in shape a broad bean pod, with a group of five (three or four paratypes) bristles near apex and below this group three (two or three in paratypes) stout bristles. Hind margin of 7*s* slightly concave at middle. Spermatheca somewhat distorted in allotype, figure in lower right-hand corner drawn from paratype.

Length, male, 1.4 millimeters, female, 2.5.

One male and four females taken off the Chinese weasel, *Putorius sinensis* from Hangchow, in 1935. Holotype, a male; allotype, a female, and three paratypes (females) in my collection.

25. Genus VERMIPSYLLA Schimkewitsch, 1885

No comb on head and pronotum. Frontal tubercle present. Eye present. Club of antennæ short, not much longer than broad. Labial palpus with ten or more segments. Ocular row composed of four or five bristles. Hind coxa without spinelets. Fifth segment of all tarsi with four pairs of lateral plantar bristles. Antepygidial bristles wanting. Gravid females with distended abdomen.

68. VERMIPSYLLA DORCADIA Rothschild, 1912.

Allied to *V. alakurt*. Tergites of thorax and abdomen bearing each two rows of bristles, anterior row dorsally more or less incomplete (almost absent in female), bristles of both rows short except two situated below stigma. Midtibia with four and hind tibia with only three pairs of long bristles at dorsal edge, including apical bristles, others reduced to slender bristles. First fore- and midtarsal segments shorter than second; hind tarsal second to fourth segments each with long apical bristles extending beyond fifth segment, thinner and shorter than those of *V. alakurt*. Abdominal sternites with only one bristle on each side.

5. Family PULICIDÆ Taschenberg, 1880

Head with or without genal comb. Eyes nearly always present. Vertical suture between bases of antennal grooves absent. Preoral flaps wanting. Thoracic segments not strongly shortened, their tergites together longer than first abdominal tergite. Pronotal comb absent or present. Abdomen without combs, with a single row of bristles to each typical tergite. Antepygidial bristles always present. Clasper of male with two movable fingers on each side. Abdomen of gravid female only slightly distended and provided, except in one genus, with only one seminal receptacle.

Subfamily PULICINÆ Tiraboschi, 1904

Club of antennæ asymmetrical, very slightly segmented on lower side, first segment of club lanceolate or spatulate. First midtarsal segment much shorter than second.

Key to the genera of Pulicinæ.

1. Pronotal comb of spines and genal comb absent.. 2.
   Pronotal comb of spines and genal comb present.. 3.
2. Mesosternite rather narrow, without a vertical sclerotized rod besides an oblique one. Ocular bristle situated lower than eye.... *Pulex* Linnæus.
   Mesosternite very broad, with a vertical sclerotized rod besides an oblique rod. Ocular bristles situated before eye............ *Xenopsylla* Glinkewicz.
3. Genal comb composed of three or less spines. Pronotal comb much reduced, with eight or less spines................................ *Archæopsylla* Dampf.
   Genal comb composed of more than three spines. Pronotal comb not reduced, with at least twelve spines.... *Ctenocephalides* Stiles et Collins.

26. Genus CTENOCEPHALIDES Stiles et Collins, 1930

Frontal tubercle absent. Eye present. Labial palpus 4-jointed. Club of antennæ distinctly segmented only on pos-

terior side. Ocular row of two bristles on gena. Genal comb of about seven to eleven rather long, pointed and recurved spines. A strong incrassation from antennal groove upwards. Two occipital rows of one bristle. Pronotal comb composed of sixteen to eighteen spines. Hind coxa with spinelets. One antepygidial bristle on each side. 8*s* of male broad.

Key to the species of Ctenocephalides.

1. Front strongly rounded; distance from frontal corner across eye to anterior edge of antennal groove equal to distance from eighth genal spine to vertex. First spine of genal comb much shorter (about one-half) than second spine.. *C. canis* (Curtis).
   Front strongly pointed; distance from frontal corner across eye to anterior edge of antennal groove about one-fifth to one-third longer than distance from eighth genal spine to vertex. First spine of genal comb slightly shorter than second spine.................................. *C. felis* (Bouché).

69. CTENOCEPHALIDES CANIS (Curtis, 1826). Text figs. 118 and 119.

Front strongly rounded. Distance from frontal corner across eye to anterior margin of antennal groove equaling that

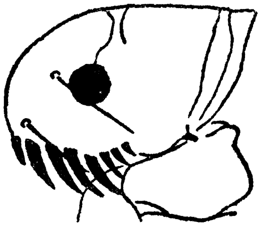


FIG. 118. *Ctenocephalides canis*, female, head. (After Rothschild.)

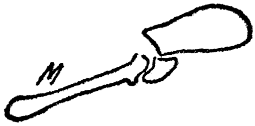


FIG. 119. *Ctenocephalides canis*, male. (After Rothschild.)

from eighth genal spine to vertex. First (anterior) spine of genal comb much shorter than second. Abdominal stigma larger.

Male.—Manubrium straight, narrow, distinctly widened at apex into a spatula. Finger sole-shaped, widening gradually towards rounded apex; finger bearing numerous setæ along edge, except basal third of dorsal margin and basal three-fourths of ventral margin.

Female.—8*t* less rounded at apex. Stylet less slender than in *C. felis.*

70. CTENOCEPHALIDES FELIS (Bouché, 1835). Text figs. 120 and 121.

Front less rounded. Distance from frontal corner across eye to anterior margin of antennal groove almost one-fifth (male) to one-third (female) longer than that from eighth genal spine

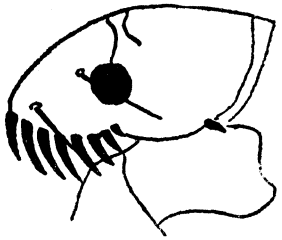


FIG. 120. *Ctenocephalides felis*, female, head. (After Rothschild.)

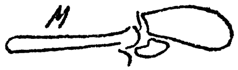


FIG. 121. *Ctenocephalides felis*, male. (After Rothschild.)

to vertex. Head much more pointed in outline. First spine of genal comb a little shorter than second. Abdominal stigma smaller.

Male.—Manubrium straight and narrow, only slightly widened at apex. Nonhairy portions of margins of finger shorter.

Female.—8*t* more rounded at apex. Stylet slenderer than in *C. canis*.

27. Genus ARCHÆOPSYLLA Dampf, 1908

Genal comb composed of one to three, usually two spines. Eye present. Labial palpus reaching much beyond apex of third segment of maxillary palpus. Pronotal comb present, much reduced. Hind coxa with a patch of spinelets on inner surface. One antepygidial bristle on each side.

71. ARCHÆOPSYLLA SINENSIS Jordan et Rothschild, 1911. Text figs. 122 and 123.

Genal comb either absent or small and pale. Head with internal incrassation from antennal groove upwards.

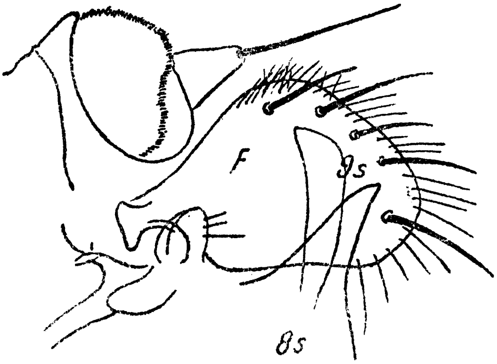


FIG. 122. *Archæopsylla sinensis*, male. (After Jordan and Rothschild.)

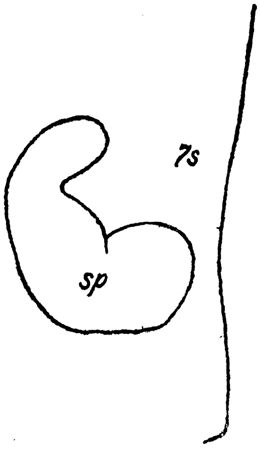


FIG. 123. *Archæopsylla sinensis*, female. (After Jordan and Rothschild.)

Male.—Ventral margin of 8*s* not denticulate. Manubrium long and narrow, apex slightly dilated and rounded. Finger very broad, apex gradually and slightly convex, ventral edge bearing a narrow membranous appendage. 9*s* small, lying within finger, anterior margin nearly straight, posterior margin strongly rounded near apical portion.

Female.—Apical margin of 7*s* straight, very slightly incurved near center. Apex of 8*t* more or less truncate. Spermatheca appearing 3-jointed, widest portion of head slightly less than twice width of tail.

28. Genus XENOPSYLLA Glinkewicz, 1907

Frontal tubercle wanting. Eye present. Labial palpus composed of four segments. Genal process almost completely closing antennal groove. Anterior angle of genal edge of head not produced into a triangular lobe. No comb on head. Club of antennæ short, distinctly segmented only on posterior side. Ocular row composed of two bristles, ocular bristle in front of eye. First and second occipital rows represented by one bristle or first row lacking. Pronotal comb lacking. Mesosternite with two sclerotized incrassations extending from insertion of coxa forwards and upwards. Hind coxa with spinelets on inner side. Fifth tarsal segment with four lateral pairs of plantar bristles besides subapical hair.

Male.—Clasper without large flap present in *Pulex.* Manubrium narrow. Upper internal portion of 9*s* not very sharply defined.

Female.—Head of spermatheca globular, base of tail not sharply defined.

72. XENOPSYLLA CHEOPIS (Rothschild, 1903). Text figs. 124 to 126.

Labial palpus reaching to apex of fore coxa. Dorsal incrassation of occiput with even contour. Episternum and sternum of metathorax separated by a vertical rodlike incrassation. Longest apical bristle of second hind tarsal segment reaching to middle of fifth segment. Antepygidial bristle not on a conelike process.

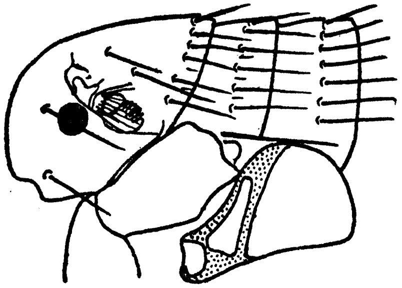


FIG. 124. *Xenopsylla cheopis*, female, head. (After Rothschild.)

Male.—Upper margin of clasper slightly convex, lower margin slightly concave. Fingers two; one narrow and

more or less straight, the other relatively broad and asymmetrical. Posterior arm of 9*s* club-shaped, gradually widening towards apex.

Female.—Stylet short. Head of spermatheca globular, tail long and strongly curved, wider at base than at head.

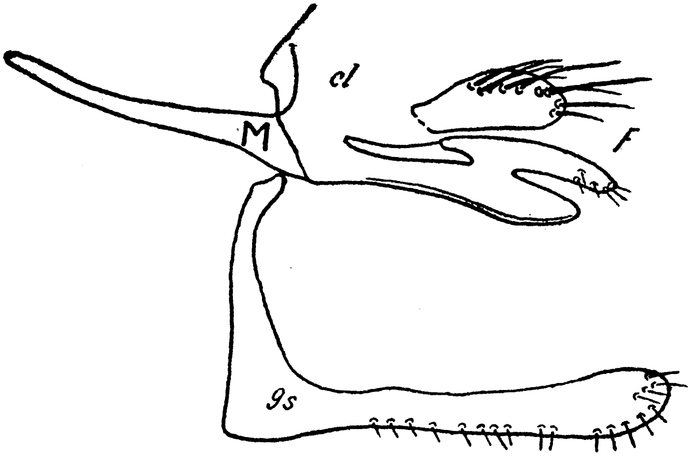


FIG. 125. *Xenopsylla cheopis*, male. (After Jordan and Rothschild.)

29. Genus PULEX Linnæus, 1758

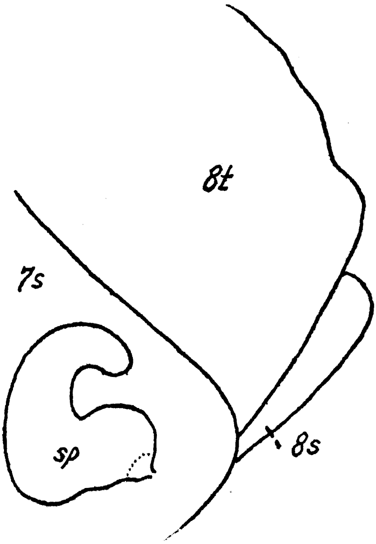


FIG. 126. *Xenopsylla cheopis*, female. (After Jordan and Rothschild.)

Frontal tubercle absent. Eye present. Labial palpus 4-jointed. Club of antenna short, distinctly segmented only on posterior side. Antennal groove closed behind. Ocular bristle lower than eye. Except for an ocular row and an occipital apical row, there is no bristle on head. Mandibles broad, short, densely serrate. Pronotum without comb. Mesosternite very narrow, with but one oblique rodlike incrassation extending from insertion of coxa forward to lower anterior margin. Hind coxa with a patch of spinelets. Fifth

tarsal segment with four pairs of lateral plantar bristles. Only one antepygidial bristle on each side. Clasper of male with two fingers of pincerlike formation covered by a third process in form of a large hairy flap.

78. PULEX IRRITANS Linnæus, 1758. Text figs. 127 to 129.

Eyes large Labial palpus reaching to about half length of fore coxa. An ocular row of two bristles. Occiput with an

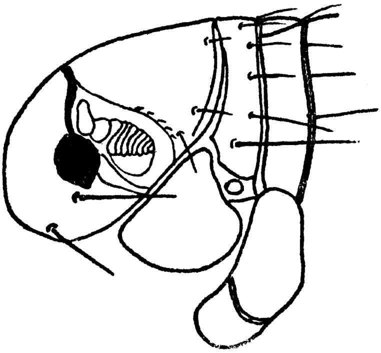


FIG. 127. *Pulex irritans*, male, head. (After Fox.)

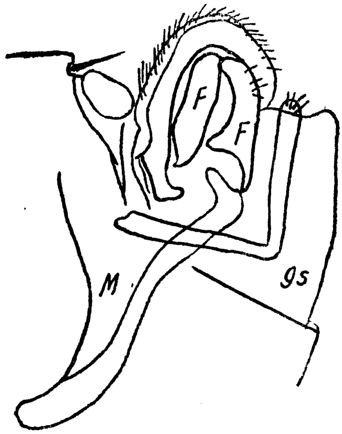


FIG. 128. *Pulex irritans*, male. (After Fox.)

apical row of three bristles. Hind femur with a lateral row of seven or more bristles on inside. Fifth hind tarsal segment longer than second.

FIG. 129. *Pulex irritans*, female. (After Fox.)

Male.—Sensory plate very short. Two strongly sclerotized processes forming a pair of pincers on inside of large flap. Manubrium with a rounded apex. 9*s* consisting of two straight arms of nearly equal width.

Female.—Dorsal edge of 8*t* projecting above sensory plate. Spermatheca with globular head and slender tail of nearly equal width.

Family HECTOPSYLLIDÆ Baker, 1904

Head without genal comb. Eyes present. Vertical suture between bases of antennal grooves absent or rudimentary. Preoral flaps wanting. Thoracic segments strongly shortened, their tergites together shorter than first abdominal tergite. Pronotal comb absent. Abdomen without combs. Antepygidial bristles

absent. Clasper of male with two movable fingers. Abdomen of gravid female exceedingly distended, provided with only one seminal receptacle.

Key to the subfamilies of Hectopsyllidæ.

1. Hind coxa with a crowded patch of short spinelets on inside. Second and third abdominal segments provided with spiracles.
ECHIDNOPHAGINÆ.
Hind coxa without a patch of spinelets. Second and third abdominal segments of female with vestigial spiracles or without spiracles.
SARCOPSYLLINÆ.

Subfamily ECHIDNOPHAGINÆ Wagner, 1927

Hind coxa with a thickly studded patch of short spinelets on inner surface. Second and third abdominal segments provided with a stigma.

30. Genus ECHIDNOPHAGA Oliff, 1886

Labial palpus 1-segmented. Head angulate in front, divided by a groove or an internal thickening from antennal groove upwards. Hind coxa anteriorly produced at apex into a broad tooth, bearing a patch of spinelets on inner side. Hind femur simple. Second to seventh abdominal segments with a stigma in both sexes. Anal segment of female with stylet.

74. ECHIDNOPHAGA GALLINACEA (Westwood, 1875). Text figs. 130 and 131.

Anterior margin of front vertical, forming obtuse angles above and below. Gena with a tooth which is rounded at apex.

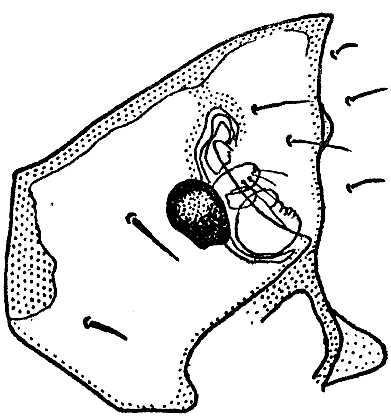


FIG. 130. *Echidnophaga gallinacea*, female, head. (After Ioff and Argyropulo.)

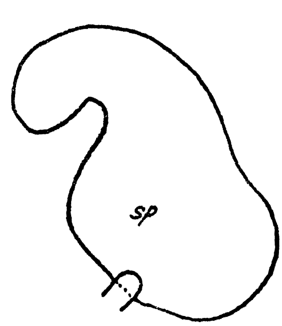


FIG. 131. *Echidnophaga gallinacea*, female. (After Fox.)

Eyes larger, situated slightly near lower genal margin. Hind margin of head with a small lateral lobe, width of lobe considerably longer than length. Genal process more or less pointed

at apex, usually not projecting beyond hind margin of head. Apex of mandible reaching to one-third or one-half of length of fore femur. Fifth tarsal segment provided with four pairs of lateral plantar bristles (fourth pair less developed than three other pairs) and, in addition, two ventral apical plantar bristles.

Subfamily SARCOPSYLLINÆ Wagner, 1927

Hind coxa without a patch of short spinelets on inner surface. Abdominal stigmata much reduced in size, obliterated on second and third segments of female.

31. Genus DERMATOPHILUS Guerin, 1838

The absence of a patch of spinelets on the inside of the hind coxa and of the toothlike projection near the base of the hind femur suffice to distinguish *Dermatophilus* from the genera of the other two subfamilies. Other generic characters are as follows: Front produced into an angular tubercle along anterior margin. Labial palpus composed of one segment. Prosternite not produced posteriorly into a distinct conical tooth. Tibia with three pairs of dorsal bristles. Tarsi very slender, some of apical bristles on second, third, and fourth hind tarsal segments very long and thin; fifth tarsal segment linear, about eight times as long as broad, with a few long and thin hairs. Claws slender, without basal projection. Female without anal stylet and without stigma on second and third abdominal tergites.

75. DERMATOPHILUS CÆCIGENA (Jordan et Rothschild, 1921). Text fig. 132.

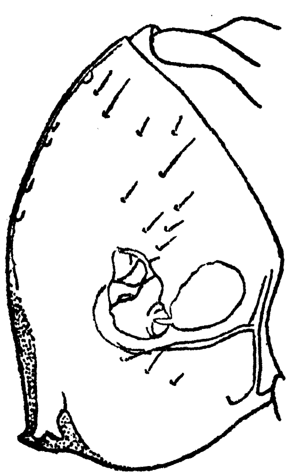


FIG. 132. *Dermatophilus cæcigena*, female, head. (After Jordan and Rothschild.)

Female.—Ovoid, tough-skinned, contracted posteriorly into a short, taillike process which exhibits sclerotized structures at tip. Largest specimen 8.5 millimeters long and 6 millimeters broad. Head similar to that of *D. cæcata*, except that the genal edge is somewhat more rounded and the area between the antennal groove and mouth parts is of more even width. Fourth joint of maxillary palpus twice as long as second, and last two joints as wide as others. Anterior extremity of abdomen produced into four rounded lobes, which almost conceal minute head, thorax, and limbs of the insect.

TABLE 3.—*Mammalian hosts of Chinese fleas.*

[The arrangement of the orders is that adopted by Howell in Mammals from China in the Collections of the United States National Museum (1929).]

Host.	Flea.	Locality.
Order Insectivora.		
Family Erinaceidæ.		
Erinaceus miodon	*Archæopsylla sinensis* J. and R.	Shensi.
Family Talpidæ.		
Scaptochirus gilliesi	*Rectofrontia jaonis* (Jord.)	Do.
"Mole"	*Palæopsylla remota* Jord.	Szechwan.
Order Chiroptera.		
Family Rhinolophidæ.		
Rhinolophus ferrumequinum nippon	*Ischnopsyllus needhamia* Hsü	Soochow.
Family Vespertilionidæ.		
Nyctalus aviator	do	Do.
Pipistrellus abramus	do	Do.
Pipistrellus sp.	*Myodopsylla trisellis* Jord.	Manchuria.
Vesperugo planeyi	*Ischnopsyllus comans* J. and R.	Peiping.
"Bat"	*Monopsyllus anisus* (Roths.)	Hangchow.
	Nycteridopsylla galba Dampf	Shanghai.
"Common house bat"	*Ischnopsyllus tateishii* Sugimoto	Hangchow.
Order Carnivora.		
Family Canidæ.		
Canis familiaris	*Ctenocephalides canis* (Curtis)	China.
	Ctenocephalides felis (Bouché)	Do.
	Pulex irritans Linn.	Do.
Family Mustelidæ.		
Mustela sp.	*Ceratophyllus kaznakovi* Wagner	East Tibet.
Putorius sinensis	*Chætopsylla hangchowensis* Liu	Hangchow.
Putorius sp.	*Ceratophyllus kaznakovi* Wagner	East Tibet.
	Rectofrontia accola Wagner	Tibet.
	Rectofrontia vicina Wagner	Do.
Family Felidæ.		
Felis domestica	*Ctenocephalides canis* (Curtis)	China.
	Ctenocephalides felis (Bouché)	Do.
	Pulex irritans Linn.	Do.

TABLE 3.—*Mammalian hosts of Chinese fleas*—Continued.

Host.	Flea.	Locality.
Order Primates.		
Family Hominidæ.		
Homo sapiens	*Ctenocephalides canis* (Curtis)	China.
	Pulex irritans Linn.	Do.
Order Rodentia.		
Family Sciuridæ.		
Citellus mongolicus?	*Ceratophyllus tesquorum mongolicus* J. and R.	Mongolia.
	Ceratophyllus tesquorum sungaris Jord.	Manchuria.
	Neopsylla bidentatiformis (Wagner)	Do.
	Ophthalmopsylla jettmari Jord.	South Manchuria.
	Ophthalmopsylla kukuschkini Ioff	Do.
	Oropsylla elana Jord.	Manchuria.
Citellus dahuricus mongolicus	*Diamanus mandarinus* (J. and R.)	Shensi.
Citellus sp.	*Rectofrontia dives* (Jord.)	South Manchuria.
Drenomys pernyi griselda	*Aceratophyllus euteles* (J. and R.)	Szechwan, Yunnan.
Marmota bobac	*Oropsylla silantiewi silantiewi* (Wagner)	Manchuria.
Marmota robusta	*Frontopsylla luculenta parilis* Jord.	Mongolia.
	Ceratophyllus dolabris (J. and R.)	Kansu.
	Ceratophyllus tesquorum famulus J. and R.	Do.
	Oropsylla silantiewi crassus (J. and R.)	Do.
Sciurotamias davidianus davidianus	*Aceratophyllus euteles* (J. and R.)	Szechwan, Yunnan.
	Paraceras crispus (J. and R.)	Szechwan.
	Stenoponia cœlestis J. and R.	Do.
Sciurotamias davidianus consobrinus	*Ceratophyllus phæopis* J. and R.	Do.
Sciurus sp.	*Neoceratophyllus trispinosus* Liu	Chekiang.
Spermophilus sp. ? (burrow)	*Ceratophyllus tesquorum sungaris* Jord.	Manchuria.
	Frontopsylla luculentus parilis Jord.	Mongolia.
Tamiops swinhoei	*Aceratophyllus euteles* (J. and R.)	Szechwan, Yunnan.

Family Cricetidæ.		
Cricetiscus campbelli	*Oropsylla elana* Jordan	Manchuria.
Cricetulus arenarius	*Ceratophyllus tesquorum sungaris* Jordan	Do.
Cricetulus furunculus	*Amphipsylla vinogradovi* Ioff	Do.
	Neopsylla bidentatiformis (Wagner)	Do.
Cricetulus griseus	do	Do.
	Rectofrontia dives (Jord.)	South Manchuria.
Cricetulus griseus fumatus	*Neopsylla bidentatiformis* (Wagner)	Manchuria.
	Ophthalmopsylla jettmari Jord.	South Manchuria.
	Ophthalmopsylla kukuschkini Ioff	Do.
Cricetulus sp.	*Ophthalmopsylla jettmari* Jord.	Do.
	Rectofrontia insolita (Jord.)	Do.
	Rectofrontia tenella (Jord.)	Manchuria.
Cricetulus triton	*Neopsylla bidentatiformis* (Wagner)	Do.
Microtus economus	*Amphipsylla mitis* Jord.	Mongolia.
	Frontopsylla luculentus parilis Jord.	Do.
Microtus sp.	*Amphipsylla tuta* Wagner	Tibet.
	Ceratophyllus kozlovi Wagner	East Tibet.
Family Spalacidæ.		
Myospalax cansus	*Neopsylla anoma* Roths.	Shensi.
Myospalax fontanieri	*Amphipsylla casis* J. and R.	Do.
	Neopsylla aliena J. and R.	Do.
Family Muridæ.		
Apodemus agrarius	*Ctenophthalmus yunnanus* Jord.	Yunnan.
	Neopsylla specialis Jord.	Do.
Apodemus silvaticus latorum	*Frontopsylla spadix spadix* (J. and R.)	Do.
Mus decumanus	*Dermatophilus cæcigena* (J. and R.)	Ningpo, Shanghai, Soochow.
Mus musculus	*Ceratophyllus fasciatus* (Bosc)	Shanghai, Soochow.
	Ctenopsyllus segnis (Schon.)	China.
	Xenopsylla cheopis (Roths.)	Canton, Hsuchow, Peiping, Shanghai.
Myotalpa aspalax	*Amphipsylla aspalacis* Jord.	Manchuria.
	Rectofrontia jaonis (Jord.)	Do.
Rattus confucianus luticolor	*Paradoxopsyllus curvispinus* Miya. and Koid.	Shensi.
Rattus griseipectus	*Neopsylla stevensi* Roths.	Szechwan.
Rattus norvegicus	*Ceratophyllus fasciatus* (Bosc)	Shanghai, Soochow.
	Ctenopsyllus segnis (Schön.)	China.
	Dermatophilus cæcigena (J. and R.)	Ningpo, Shanghai, Soochow.
	Monopsyllus anisus (Roths.)	Hangchow, Hsuchow, Manchuria, Peiping.
	Xenopsylla cheopis (Roths.)	Canton, Hsuchow, Peiping, Shanghai.

TABLE 3.—*Mammalian hosts of Chinese fleas*—Continued.

Host.	Flea.	Locality.
Rattus norvegicus	*Frontopsylla elatus botis* Jord.	South Manchuria.
Rattus rattus	*Pectinoctenus adalis* Jord.	Manchuria.
	Ctenopsyllus segnis (Schön.)	China.
	Xenopsylla cheopis (Roths.)	Canton, Hsuchow, Peiping, Shanghai.
Family Zapodidæ.		
Zapus sp. (burrow)	*Ceratophyllus tesquorum sungaris* (Jord.)	Manchuria.
Family Dipodidæ.		
Allactaga mongolica	*Frontopsylla luculentus parilis* Jord.	Mongolia.
	Ophthalmopsylla præfectus pernix Wagner	Do.
Rodentia of uncertain position	*Ophthalmopsylla kiritschenkoi* Wagner	Do.
Order Lagomorpha.		
Family Ochotonidæ.		
Ochotona alpina	*Amphalius runatus* (J. and R.)	Manchuria, Mongolia.
Ochotona cansa	*Aceratophyllus euteles* (J. and R.)	Szechwan, Yunnan.
	Ceratophyllus sinicus Jord.	Szechwan.
	Frontopsylla spadix cansa Jord.	Do.
	Geusibia torosa Jord.	Do.
Ochotona curzoniæ	*Amphalius clarus* (J. and R.)	Tibet.
	Ceratophyllus sparsilis (J. and R.)	Do.
Ochotona dahurica	*Ampahalius runatus* (J. and R.)	Manchuria, Mongolia.
	Frontopsylla luculenta luculenta (J. and R.)	Manchuria.
	Frontopsylla luculenta parilis Jord.	Mongolia.
	Frontopsylla wagneri Ioff	Do.
	Neopsylla bidentatiformis (Wagner)	Manchuria.
	Ophthalmopsylla præfectus pernix Jord.	Mongolia.
	Rectofrontia dahurica (J. and R.)	Manchuria.
Ochotona thibetana	*Frontopsylla spadix cansa* Jord.	Szechwan.

Family Leporidæ.		
Ellobius tancrei	*Ceratophyllus læviceps ellobii* Wagner	Mongolia.
	Frontopsylla hetera Wagner	Do.
	Paradoxopsyllus conveniens Wagner	Do.
Oryctolagus cuniculus* var. *domesticus	*Pulex irritans* Linn.	Hangchow.
Order Artiodactyla.		
Family Cervidæ.		
Capreolus bedfordi	*Vermipsylla dorcadia* Roths.	Shensi.
Callasciurus erythræus gloveri	*Aceratophyllus euteles* (R. and R.)	Szechwan, Yunnan.
Dignus sowerbyi	*Neopsylla compar* J. and R.	Shensi.
Family Bovidæ.		
Anteliomys custos	*Ctenophthalmus dinormus* Jord.	Szechwan.
	Ctenophthalmus parcus Jord.	Do.
	Neopsylla stevensi Roths.	Do.
	Paradoxopsyllus custodis Jord.	Do.
	Stenischia mirabilis Jord.	Do.
Eothenomys proditor	*Neopsylla honora* Jord.	Yunnan.
Gazella subgutturosa	*Vermipsylla dorcadia* Roths.	Shensi.
Ovis aries	*Ctenocephalides canis* (Curtis)	Hangchow.
Unknown mammal	*Paraceras sinensis* (Liu)	Szechwan.
Host not given	*Ceratophyllus gallinæ* (Schrank)	Mongolia.
	Echidnophaga gallinacea (Westw.)	Shanghai.

BIBLIOGRAPHY

[Starred references deal with fleas of China.]

1. BACOT, A. W. A study of the bionomics of the common rat fleas and other species associated with human habitations, with special reference to the influence of temperature and humidity at various periods of the life history of the insect. Journ. Hyg. 8 Plague Suppl. 3 (1914) 447–654.
2. BACOT, A. W., and C. J. MARTIN. Observations on the mechanism of the transmission of plague by fleas. Journ. Hyg. 8 Plague Suppl. 3 (1914) 423–438.
3. BACOT, A. W., and W. G. RIDEWOOD. Observations on the larvæ of fleas. Parasitol. 7 (1914) 157–175.
4. BAKER, C. F. A revision of the American Siphonaptera. Proc. U. S. Nat. Mus. 27 (1904) 365–469.
5. BAKER, C. F. The classification of the American Siphonaptera. Proc. U. S. Nat. Mus. 29 (1905) 121–170.
6. BEDFORD, G. A. H. A synoptic check-list and host-list of the ectoparasites found on South African Mammalia, Aves and Reptilia. 2d ed. Rept. Vet. Res. S. Afr. 18 (1932) 429–462.
*7. BLANDFORD, W. F. H. The chigoe in Asia. Ent. Mon. Mag. 30 (1894) 228–230.
8. BUXTON, P. A. Siphonaptera. Insects of Samoa. Brit. Mus. 7 fasc. 2 (1928) 53, 54.
9. BUXTON, P. A. Studies on the biology of fleas. London Naturalist 1931 (1932) 39–42.
10. CHAPIN, E. A. New species of North American Siphonaptera. Bull. Brooklyn Ent. Soc. 14 (1919) 49–62.
11. CHAPIN, E. A. Remarks on the genus Hystrichopsylla Tasch. with description of a new species. Proc. Ent. Soc. Wash. 23 (1921) 25–27.
*12. CHEN, H. T., and W. A. RILEY. Notes on fleas of Canton China rats. Lingnan Sci. Journ. 11 (1932) 445–448.
13. CRAGG, F. W. The distribution of the Indian species of the genus Xenopsylla, with reference to the immunity of certain areas from plague epidemics. Ind. Journ. Med. Res. Spec. Ind. Sc. Congress (1920) 29–34.
14. DALLA TORRE, C. G. Aphaniptera orbis terrarum (synopsis praecursoria). Ber. naturw. med. Ver. Innsbruck 39 (1924) 1–29.
15. DAMPF, A. Eine neue Nycteridopsylla aus Shanghai. Zool. Anz. 36 (1910) 11–15.
16. DAMPF, A. Eine neue Aphanipteren-Art (Ischnopsyllus dolosus, sp. nov.) aus dem Kaukasus. Revue Russ. Ent. 12 (1912) 41–59.
17. DUNN, L. H., and R. R. PARKER. Fleas found on wild animals in the Bitterroot Valley, Montana. U. S. Pub. Health Rept. 38 (1923) 2763–2775.
18. EWING, H. E. Notes on the taxonomy and natural relationships of fleas, with descriptions of four new species. Parasitol. 16 (1924) 341–354.
19. EWING, H. E. A collection of fleas from the Island of Hawaii. Proc. Ent. Soc. Wash. 26 (1924) 209, 210.

20. EWING, H. E. A new flea from Alaska. Proc. Biol. Soc. Wash. 40 (1927) 89, 90.

21. EWING, H. E. Notes on the siphonapteran genus Catallagia Roths. including the description of a new species. Proc. Biol. Soc. Wash. 42 (1929) 125–128.

22. EWING, H. E. A Manual of External Parasites (1929) 153–203.

23. EWING, H. E. Some factors affecting the distribution of and variation in North American ectoparasites. American Naturalist 65 (1931) 360–369.

24. FOX, C. The taxonomic value of the copulatory organs of the females in the order Siphonaptera. U. S. Pub. Health Serv. Hyg. Lab. Bull. 97 (1914) 19–22.

25. FOX, C. Insects and disease of man (1925) 112–142.

26. FOX, C. Some new Siphonaptera from California. Pan Pacific Ent. 2 (1926) 182–185.

27. FOX, C. Some new Siphonaptera. Trans. Amer. Ent. Soc. 53 (1927) 209–212.

28. GOLOV, D., and I. IOFF. Puces de Spermophiles porteuses de l'infection pesteuse durant l'hiver. Rev. Microb. Epid. 5 (1926) 239–251.

29. HENDERSON, J. R. A note on some external characters of larvæ of Xenopsylla cheopis. Parasitol. 20 (1928) 115–118.

*30. HERTIG, M., and T. F. HUANG. A rat-flea survey of Peking. Amer. Journ. Trop. Med. 10 (1929) 521–525.

31. HICKS, E. P. The relation of rat fleas to plague in Shanghai. Journ. Hyg. 26 (1927) 163–169.

32. HOWELL, A. B. Mammals from China in the collections of the U. S. National Museum. Proc. U. S. Nat. Mus. 75 (1929) 1–82.

*33. HSÜ, Y. C. Two new species of insect parasites of the bat in Soochow. Peking Nat. Hist. Bull. 9 (1935) 293–298.

*34. HSÜ, Y. C. A second new species of bat flea from Soochow. Peking Nat. Hist. Bull. 10 (1936) 137–139.

35. INGRAM, A. New fleas from South African rodents. Bull. Ent. Res. 17 (1927) 289–293.

36. INGRAM, A. Three new South African Xenopsylla. Bull. Ent. Res. 18 (1928) 371–375.

37. IOFF, I. Über neue Aphanipteren in der Sammlung des zoologischen Museums der Akademie der Wissenschaften. Ann. Mus. Zool. Acad. Sci. USSR 28 (1927) 407–439.

38. IOFF, I. Materialen zum Studium der Ektoparasitenfauna im S.–O. Russlands. IV, Flöhe der Murmeltiere (Marmota) und der Gelbziesel (Citellus fulvus), Rev. Microbiol. Epidémiol. 6 (1927) 316–323; V, Flöhe der Springmäuse (Dipodidae); VI, Flöhe der Blindmäuse (Spalacidae); VII, Die Flöhe der Steppeniltisse. Ber. Mikrob. Staats-Inst. Rostow am Don No. 8 (1929) 60 pp.; VIII, Flöhe der Ellobius talpinus, Rev. Microb. Epidémiol. 14 (1935) 79–86.

39. IOFF, I. Zur Systematik und Oekologie der Flöhe der Springmäuse (Dipodidae). Zoöl. Jahrb. 58 (1929) 359–388.

40. IOFF, I. Über Xenopsylla conformis W. und einige verwandte Aphaniptera-Arten. Zool. Anz. 92 (1930) 191–206.

41. IOFF, I. Flöhe Russlands, insbesondere der Gattungen Stenoponia J. et R., Coptopsylla J. et R. und Chaetopsylla Koh. Zeit. Parasitenkunde 7 (1934) 363–391.
42. IOFF, I. Über die Geographie der Ziesel-flöhe im Zusammenhang mit der Geschichte der Ausbreitung der Ziesel. Mag. Parasit. Inst. Zool. Acad. des Sci. USSR 6 (1936) 313–361.
43. IOFF, I. Zur Systematik der Flöhe aus der Unterfamilie Ceratophyllinae. Zeit. für Parasitenkunde 9 (1936) 73–124.
44. IOFF, I., und A. ARGYROPULO. Die Flöhe Armeniens. Zeit. für Parasitenkunde 7 (1934) 138–166.
45. IOFF, I., und N. EFREMOVA. Zur Frage über Fauna und Biologie der Flöhe an Haustieren in Mittelasien. Meditzinskaya Muisl Uzebekistana (4) 4 (1927) 1–10.
46. IOFF, I., und V. TIFLOV. Zur Fauna und Oekologie der Flöhe der Waldsteppen. Mag. Parasit. 1 (1930) 193–227.
47. JORDAN, K. On Xenopsylla and allied genera of Siphonaptera. Intern. Ent.-Kongr. Zürich 1925 2 (1926) 593–627.
48. JORDAN, K. Siphonaptera collected during a visit to the Eastern U. S. of North America in 1927. Nov. Zoöl. 34 (1928) 178–188.
49. JORDAN, K. On some problems of distribution, variability and variation in North American Siphonaptera. 4th Intern. Congr. Ent. Ithaca 2 (1928) 489–499.
50. JORDAN, K. Notes on North American fleas. Nov. Zool. 35 (1929) 28–39.
51. JORDAN, K. On a small collection of Siphonaptera from the Adirondacks with a list of the species known from the state of New York. Nov. Zool. 35 (1929) 168–177.
52. JORDAN, K. Some new Palæarctic fleas. Nov. Zool. 35 (1929) 178–186.
*53. JORDAN, K. Some Old-World Siphonaptera. Nov. Zool. 35 (1929) 40, 41.
54. JORDAN, K. On fleas collected by Dr. H. M. Jettmar in Mongolia and Manchuria in 1927 and 1928. Nov. Zool. 35 (1929) 155–164.
55. JORDAN, K. Three new Old World fleas. Nov. Zool. 35 (1931) 144–147.
56. JORDAN, K. Three new species of Neopsylla from the Oriental Region. Nov. Zoöl. 36 (1931) 220–224.
57. JORDAN, K. New Oriental fleas. Nov. Zool. 38 (1932) 267–275.
58. JORDAN, K. Notes on Siphonaptera. Nov. Zool. 38 (1932) 291–294.
*59. JORDAN, K. Siphonaptera collected by Harold Stevens on the Kelley-Roosevelt Expedition in Yunnan and Szechuan. Nov. Zool. 38 (1932) 276–290.
60. JORDAN, K. A survey of the classification of the American species of Ceratophyllus s. lat. Nov. Zool. 39 (1933) 70–79.
61. JORDAN, K., and N. C. ROTHSCHILD. A revision of the Sarcopsyllidae, a family of Siphonaptera. Thompson-Yates Lab. Rep. N. Ser. 7 (1906) 15–72.
62. JORDAN, K., and N. C. ROTHSCHILD. Some new Siphonaptera from China. Proc. Zoöl. Soc. London (1911) 365–392.

63. JORDAN, K., and N. C. ROTHSCHILD. Katalog der Siphonapteren des königlichen Museums in Berlin. Nov. Zool. 18 (1911) 57–89.
64. JORDAN, K., and N. C. ROTHSCHILD. On Siphonaptera collected in Algeria. Nov. Zool. 19 (1912) 357–372.
65. JORDAN, K., and N. C. ROTHSCHILD. Siphonaptera collected by Mr. Robin Kemp in tropical Africa. Nov. Zool. 20 (1913) 528–581.
66. JORDAN, K., and N. C. ROTHSCHILD. On some Siphonaptera collected by W. Rückbell in East Turkestan. Ectop. 1 (1915) 1–24.
67. JORDAN, K., and N. C. ROTHSCHILD. On Ceratophyllus fasciatus and some allied Indian species of fleas. Ectop. 1 (1921) 178–198.
68. JORDAN, K., and N. C. ROTHSCHILD. Eight new Ceratophylli. Ectop. 1 (1921) 163–177.
69. JORDAN, K., and N. C. ROTHSCHILD. A new species of Sarcopsyllidae. Ectop. 1 (1921) 131–132.
*70. JORDAN, K., and N. C. ROTHSCHILD. New genera and species of bat-fleas. Ectop. 1 (1921) 142–162.
*71. JORDAN, K., and N. C. ROTHSCHILD. New Siphonaptera. Ectop. 1 (1922) 266–283.
*72. JORDAN, K., and N. C. ROTHSCHILD. On some Siphanoptera from the Eastern Hemisphere. Ectop. 1 (1923) 293–308.
73. KOPSTEIN, F. Die Oekologie der javanischen Siphonapteren und ihre Bedeutung fur die Epidemiologie der Pest. Z. Morph. Oekol. Tiere 24 (1932) 408–434.
74. LESSON, H. S. Methods of rearing and maintaining large stocks of fleas and mosquitoes for experimental purposes. Bull. Ent. Res. 23 (1932) 25–31.
75. LIU, C. Y. Catalogue of Chinese Synoptera. Lingnan Sci. Journ. 15 (1936) 379–390, 583–594.
*76. LIU, C. Y. On the unrecorded male of the bat flea, Ischnopsyllus taeteishii Sugimoto. China Journ. Arts and Sci. 23 (1935) 306–310.
77. LIU, C. Y. A new Chinese flea. Peking Nat. Hist. Bull. 9 (1935) 273–275.
78. LUNDBLAD, O. Zur Kenntnis der Flöhe. Zool. Anz. 70 (1927) 7–26.
79. MIYAJIMA, M., and M. KOIDSUMI. On the study of the Japanese rat fleas. Journ. Bact. (1909) 1–46.
80. NEGISHI, H. Statistical observations on rats bearing Echidnophaga gallinacea Westw. in the city of Kobe. Oyo-Dobuts. Zasshi 6 (1934) 17–33.
81. OHMORI, N. On the fleas of Formosa. Oyo-Dobuts. Zasshi 8 (1936) 158–164.
82. OUDEMANS, A. C. Aanteekeningen over Suctoria v. 'sGravenhage. Ber. Ent. Ned. 2 (1906) 131–134.
83. OUDEMANS, A. C. Neue Ansichten über die Morphologie des Flohkopfes, sowie über die Ontogenie, Phylogenie und Systematik der Flöhe. Nov. Zool. 16 (1910) 133–158.
84. PATTON, W. S., and F. W. CRAGG. A textbook of Medical Entomology (1913) 434–477.
85. PERFILJEW, P. Zur Anatomie der Flohlarven. Rev. Microbiol. Epidémiol. 6 (1927) 329–341.

*86. RILEY, W. A. The ear chigoe of rats in China, Tunga caecigena J. and R. Lingnan Sci. Journ. 11 (1932) 285–287.

87. ROTHSCHILD, M. Siphonaptera from western Australia. Nov. Zool. 40 (1936) 3–16.

88. ROTHSCHILD, N. C. Casual notes on fleas. Nov. Zool. 2 (1895) 66.

89. ROTHSCHILD, N. C. Contributions to the knowledge of the Siphonaptera. Nov. Zool. 5 (1898) 533–544.

90. ROTHSCHILD, N. C. Further contributions to the knowledge of the Siphonaptera. Nov. Zool. 10 (1903) 317–325.

91. ROTHSCHILD, N. C. Further contributions to the knowledge of the Siphonaptera. Nov. Zool. 11 (1904) 602–653.

92. ROTHSCHILD, N. C. Note on the species of fleas found upon rats, Mus rattus and Mus decumanus, in different parts of the world, and on some variations in the proportion of each species in different localities. Journ. Hyg. 6 (1906) 483–485.

93. ROTHSCHILD, N. C. The physiological anatomy of the mouth parts and alimentary canal of the Indian rat flea, Pulex cheopis Rothschild. Journ. Hyg. 6 (1906) 486–495.

94. ROTHSCHILD, N. C. On some American, Australian and Palæarctic Siphonaptera. Nov. Zool. 16 (1909) 61–68.

95. ROTHSCHILD, N. C. Synopsis of fleas found on rats and mice. Bull. Ent. Res. 1 (1910) 89–98.

96. ROTHSCHILD, N. C. On the bat-fleas described by Kolenati. Nov. Zool. 18 (1911) 48–56.

97. ROTHSCHILD, N. C. Some new genera and species of Siphonaptera. Nov. Zool. 18 (1911) 117–122.

*98. ROTHSCHILD, N. C. Report on a small collection of fleas from India and China. Rec. Ind. Mus. 6 (1911) 43, 44.

*99. ROTHSCHILD, N. C. Description of three new species of Siphonaptera, in Clark, R. S. and A. de C. Sowerby's "through Shen Kan." Appendix IV (1912) 194–203.

100. ROTHSCHILD, N. C. On Neopsylla and some allied genera of Siphonaptera. Ectop. 1 (1915) 30–44.

101. ROTHSCHILD, N. C. Contribution to our knowledge of the Siphonaptera fracticipita. Nov. Zool. 22 (1915) 302–308.

102. ROTHSCHILD, N. C. A synopsis of the British Siphonaptera. Ent. Mon. Mag. (3) 1 (1915) 49–112.

103. ROUBAUD, E. Une nouvelle espèce de puce-chique penetrante, parasite des rats en Chine: Dermatophilus lagrangei n. sp. Bull. Soc. Patho. Exotique 18 (1925) 399–403.

104. SHARIF, M. A revision of the Indian Siphonaptera. I. Family Pulicidae. Rec. Ind. Mus. 32 (1930) 29–62.

105. SIKES, E. K. Larvæ of Ceratophyllus wickhami and other species of fleas. Parasitol. 22 (1930) 242–259.

106. STILES, C. W., and B. J. COLLINS. Ctenocephalides, a new genus of fleas, type Pulex canis. U. S. Pub. Health Rept. 45 (1930) 1308–1310.

107. SUGIMOTO, M. Notes on fleas in Formosa. Trans. Nat. Hist. Soc. Formosa 23 (1933) 116–145.

108. TASCHENBERG, O. Die Flöhe. Halle (1880).
109. TIFLOV, V. E. Contribution à l'étude des aphanipteres du gouvernèment de Saratov. Comptes Rendus du Premier Congrès Antipesteux de l' USSR (1927) 268–275.
110. TIFLOV, V. E., and E. I. PAVLOV. Materials for the study of the Transbaikalian flea fauna. Rev. Microbiol. **15** (1936) 79–88.
111. WAGNER, J. Zur Frage über den Kopfbau der Aphanipteren mit Berücksichtigung ihrer Systematik. Zool. Anz. **67** (1926) 289–292.
112. WAGNER, J. Über die Einteilung der Gattung Ceratophyllus Curtis. Konowia **6** (1927) 101–113.
113. WAGNER, J. Zur Benennung Ctenopsyllus Kolenati. Konowia **6** (1927) 287–290.
114. WAGNER, J. Über die nordamerikanische Ceratophylli welche auf Zieseln und Murmeltieren leben. Konowia **8** (1929) 311–315.
115. WAGNER, J. Über neue palaearktische Floh-Arten (Aphaniptera). I, Ann. Mus. Zoöl. Acad. Sci. USSR **30** (1929) 21–33; II, ibid., 531–547.
116. WAGNER, J. Katalog der palaearktischen Aphanipteren. Wien (1930) 55.
117. WAGNER, J. Zur Morphologie der letzten Abdominalsegmente der Flöhe. Zool. Jahrb. **56** (1932) 54–120.
118. WAGNER, J. Fünf neue palaearktische Flöhe. Konowia **11** (1932) 273–280.
119. WAGNER, J. Aphanipterologische Notizen, II. Eine Erklärung der Eigentümlichkeiten im Baue des 8. abdominalen Sternits bei Ceratophyllinen-Männchen. Konowia **12** (1933) 51–54.
120. WAGNER, J. Concerning Jordan's Notes on Siphonaptera. Konowia **12** (1933) 89–94.
121. WAGNER, J. Zweiter Nachtrag zum Kataloge der palaearktischen Aphanipteren, 1930. Konowia **12** (1933) 212–216.
122. WAGNER, J. Nachtrag zur Kenntnis der letzten Abdominalsegmente der Flöhe. Zool. Jahrb. **57** (1933) 365–374.
123. WAGNER, J. Weitere Einteilung der Gattung Ceratophyllus Curtis. Konowia **13** (1934) 260–263.
124. WAGNER, J. Dritter Nachtrag zum Kataloge der palaearktischen Aphanipteren, 1930. Konowia **14** (1935) 217–224.
125. WAGNER, J. Aphanipterologische Notizen, IV. Über das Reduzieren des 8. Abdominalsternits bei den Männchen einer Ceratophyllinengruppe. Konowia **14** (1936) 85–96.
126. WAGNER, J. Flöhe, Aphaniptera (Siphonaptera, Suctoria). Tierwelt Mitteleur. VI. Pt. 3. 2. Lief. (1936) xvii + 24 pp.
127. WAGNER, J., and A. ARGYROPULO. Aphanipterenfauna des Aserbeidschan nebst Bemerkungen über die Gattung Nosopsyllus Jord. Zeit. Parasitenkunde **7** (1934) 217–232.
128. WAGNER, J., and A. VASSILIEFF. Tableaux analytiques pour la determination des puces rencontrees en Algerie et Tunisie. Arch. Inst. Pasteur Tunis **21** (1933) 431–467.

ILLUSTRATIONS

TEXT FIGURES

FIG. 30. *Amphalius clarus*, male. (After Jordan and Rothschild.)
31. *Amphalius clarus*, female. (After Jordan and Rothschild.)
32. *Paraceras crispus*, male. (After Jordan and Rothschild.)
33. *Paraceras crispus*, female. (After Jordan and Rothschild.)
34. *Paraceras sinensis*, female. (Author's drawing.)
35. *Neoceratophyllus trispinosus* sp. nov., male. (Author's drawing.)
36. *Neoceratophyllus trispinosus* sp. nov., female. (Author's drawing.)
37. *Aceratophyllus euteles*, male. (After Jordan.)
38. *Aceratophyllus euteles*, female. (After Jordan and Rothschild.)
39. *Paradoxopsyllus curvispinus*, male, variations. (*A*, after Miyajima and Koidzumi; *B*, after Rothschild.)
40. *Paradoxopsyllus curvispinus*, female. (After Rothschild.)
41. *Paradoxopsyllus custodis*, male. (After Jordan.)
42. *Paradoxopsyllus custodis*, female. (After Jordan.)
43. *Ophthalmopsylla præfectus pernix*, male. (After Jordan.)
44. *Ophthalmopsylla præfectus pernix*, female. (After Jordan.)
45. *Ophthalmopsylla kukuschkini*, male. (After Ioff.)
46. *Ophthalmopsylla jettmari*, male. (After Jordan.)
47. *Ophthalmopsylla jettmari*, female. (After Jordan.)
48. *Ophthalmopsylla kiritschenkoi*, female. (After Wagner.)
49. *Frontopsylla elata botis*, male. (After Jordan.)
50. *Frontopsylla elata botis*, female. (After Jordan.)
51. *Frontopsylla luculenta luculenta*, male. (After Jordan and Rothschild.)
52. *Frontopsylla luculenta luculenta*, female. (After Jordan and Rothschild.)
53. *Frontopsylla luculenta parilis*, male. (After Jordan.)
54. *Frontopsylla wagneri*, male. (After Ioff.)
55. *Frontopsylla wagneri*, female, variations of seventh sternite. (After Ioff.)
56. *Frontopsylla hetera*, female. (After Wagner.)
57. *Frontopsylla spadix spadix*, female. (After Jordan and Rothschild.)
58. *Frontopsylla spadix cansa*, male. (After Jordan.)
59. *Frontopsylla spadix cansa*, female, variations of seventh sternite. (After Jordan.)
60. *Geusibia torosa*, male. (After Jordan.)
61. *Geusibia torosa*, female. (After Jordan.)
62. *Amphipsylla tuta*, male. (After Wagner.)
63. *Amphipsylla aspalacis*, male. (After Jordan.)
64. *Amphipsylla aspalacis*, female. (After Jordan.)
65. *Amphipsylla casis*, male. (After Jordan and Rothschild.)
66. *Amphipsylla casis*, female. (After Jordan and Rothschild.)
67. *Amphipsylla mitis*, male. (After Jordan.)
68. *Amphipsylla mitis*, female. (After Jordan.)
69. *Amphipsylla vinogradovi*, male. (After Ioff.)
70. *Amphipsylla vinogradovi*, female, variations of seventh sternite. (After Ioff.)
71. *Ctenophthalmus parcus*, male. (After Jordan.)
72. *Ctenophthalmus parcus*, female, variations of seventh sternite. (After Jordan.)

FIG. 73. *Ctenophthalmus yunnanus*, male. (After Jordan.)
74. *Ctenophthalmus dinormus*, female. (After Jordan.)
75. *Stenischia mirabilis*, female. (After Jordan.)
76. *Rectofrontia dahurica*, male. (After Jordan and Rothschild.)
77. *Rectofrontia tenella*, male. (After Jordan.)
78. *Rectofrontia tenella*, female. (After Jordan.)
79. *Rectofrontia dives*, male. (After Jordan.)
80. *Rectofrontia dives*, female. (After Jordan.)
81. *Rectofrontia jaonis*, female. (After Jordan.)
82. *Rectofrontia insolita*, male. (After Jordan.)
83. *Rectofrontia insolita*, female. (After Jordan.)
84. *Rectofrontia accola*, male. (After Wagner.)
85. *Rectofrontia vicina*, male. (After Wagner.)
86. *Stenoponia cœlestis*, female, head. (After Jordan and Rothschild.)
87. *Stenoponia cœlestis*, female. (After Jordan and Rothschild.)
88. *Palæopsylla remota*, female. (After Jordan.)
89. *Ctenopsyllus segnis*, female, head. (After Rothschild.)
90. *Ctenopsyllus segnis*, female, spermatheca. (After Fox.)
91. *Pectinoctenus adalis*, male. (After Jordan.)
92. *Neopsylla bidentatiformis*, male, head. (Author's drawing.)
93. *Neopsylla bidentatiformis*, male. (Author's drawing.)
94. *Neopsylla bidentatiformis*, female. (Author's drawing.)
95. *Neopsylla anoma*, male. (After Rothschild.)
96. *Neopsylla anoma*, female. (After Rothschild.)
97. *Neopsylla aliena*, male. (After Jordan and Rothschild.)
98. *Neopsyla aliena*, female. (After Jordan and Rothschild.)
99. *Neopsyla compar*, female. (After Jordan and Rothschild.)
100. *Neopsylla stevensi*, male. (After Rothschild.)
101. *Neopsylla stevensi*, female. (After Rothschild.)
102. *Neopsylla specialis*, male. (After Jordan.)
103. *Neopsylla honora*, male. (After Jordan.)
104. *Ischnopsyllus comans*, male, head. (After Jordan and Rothschild.)
105. *Ischnopsyllus comans*, male. (After Jordan and Rothschild.)
106. *Ischnopsyllus comans*, female. (After Jordan and Rothschild.)
107. *Ischnopsyllus needhamia*, male. (Author's drawing.)
108. *Ischnopsyllus needhamia*, female. (Author's drawing.)
109. *Ischnopsyllus tateishii*, male. (Author's drawing.)
110. *Ischnopsyllus tateishii*, female. (Author's drawing.)
111. *Myodopsylla trisellis*, male. (After Jordan.)
112. *Myodopsylla trisellis*, female. (After Jordan.)
113. *Nycteridopsylla galba*, male, part of head. (After Dampf.)
114. *Nycteridopsylla galba*, male. (Author's drawing.)
115. *Chætopsylla hangchowensis* sp. nov., male, head. (Author's drawing.)
116. *Chætopsylla hangchowensis* sp. nov., male. (Author's drawing.)
117. *Chætopsylla hangchowensis* sp. nov., female. (Author's drawing.)
118. *Ctenocephalides canis*, female, head. (After Rothschild.)
119. *Ctenocephalides canis*, male. (After Rothschild.)
120. *Ctenocephalides felis*, female, head. (After Rothschild.)
121. *Ctenocephalides felis*, male. (After Rothschild.)
122. *Archæopsylla sinensis*, male. (After Jordan and Rothschild.)

FIG. 123. *Archæopsylla sinensis*, female. (After Jordan and Rothschild.)
124. *Xenopsylla cheopis*, female, head. (After Rothschild.)
125. *Xenopsylla cheopis*, male. (After Jordan and Rothschild.)
126. *Xenopsylla cheopis*, female. (After Jordan and Rothschild.)
127. *Pulex irritans*, male, head. (After Fox.)
128. *Pulex irritans*, male. (After Fox.)
129. *Pulex irritans*, female. (After Fox.)
130. *Echidnophaga gallinacea*, female, head. (After Ioff and Argyropulo.)
131. *Echidnophaga gallinacea*, female. (After Fox.)
132. *Dermatophilus cæcigena*, female, head. (After Jordan and Rothschild.)

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 70 OCTOBER, 1939 No. 2

THE FERMENTATION OF CASSAVA AND MOLASSES FOR THE PRODUCTION OF ACETONE AND NORMAL BUTYL ALCOHOL

By MARCOS A. TUBANGUI, VICTORIA A. MASILUÑGAN, and DOLORES HIPOLITO

Of the Bureau of Science, Manila

Of the various fermentation processes the production of acetone and normal butanol probably ranks second only to the yeast-alcohol industry in commercial importance, due to the fact that these two chemicals or their derivatives are used extensively as solvents, especially for the manufacture of lacquers, paints, varnishes, dopes, and explosives; as raw materials for the preparation of esters, perfumes, and pharmaceuticals; and as blending agents or stabilizers for composite motor fuels.

In the United States corn has generally been employed for the production of acetone and normal butanol. Lately, due to a tendency for the price of this cereal to go up as a result of crop reduction programs, investigators have been occupied in the search for cheaper raw materials. Recently Underkofler, Fulmer, and Rayman(8) indicated the possibility of employing xylose as a source of solvents.

In the Philippines there are a number of minor agricultural crops, such as the different kinds of tubers, which are rich in starch. If it can be shown that some of these can be used profitably as raw materials for the manufacture of industrial chemicals and other useful products, some of the farmers may be encouraged to grow them on a large scale, thus providing one of the possible inducements for the raising of diversified crops.

It appears from available literature that cassava (*Manihot utilissima* Pohl) is one of the few amylaceous materials that have not been employed for the production of acetone and normal butanol. At least cassava is not mentioned specifically as a source of solvents by Smyth and Obold.(6) In the case of molasses, a number of procedures have been described regarding its utilization in the butyl-acetonic fermentation process; but, according to Owen,(4) many of these procedures have not been successful from a commercial standpoint.

MATERIALS AND METHODS

Bacterial culture.—The original organism was isolated from rice field soil in October, 1937, according to the method of Weyer and Rettger.(10) It agrees in its cultural and morphological characteristics with two strains of *Clostridium acetobutylicum* (Weizmann) which were kindly furnished by Prof. E. B. Fred, of the University of Wisconsin, whose courtesy we wish gratefully to acknowledge. It was kept as a spore culture in soil and handled in the usual manner, 6.3 per cent sterile corn mash [1] being used as stock medium for the cultures and control fermentation tests.

It was observed in the beginning that, although the organism fermented corn mash vigorously with good yields of solvents, it was unable to utilize completely either the cassava or molasses, in spite of the presence of what were later found to be adequate nutrients. This difficulty was overcome by gradually acclimatizing it to grow in the presence of these materials through repeated subculturing, sporulation, and "heat-shocking," as practiced by Underkofler, Christensen, and Fulmer.(7) By this method we were able to develop two substrains, one of which was especially adopted for cassava and the other for molasses.

Preparation of mashes.—The cassava material used is known as "gaplex," and consists of dried sliced tubers of the plant. It was ground into a powder, and its starch content and the sugar content of the molasses determined according to the methods of the Association of Official Agricultural Chemists (1935). Unless otherwise stated, the mashes were prepared in such concentrations that their total carbohydrate contents were equivalent to 4 per cent starch. These mashes were sterilized in an autoclave for 2 hours at 15 pounds pressure. After sterilization they were cooled in running water and inoculated at once, 5 cc

[1] At this concentration the corn mash contained 4 per cent starch. Expressed in terms of dextrose, the carbohydrate content was $(4 \div 0.9 =)$ 4.44 per cent.

of an active bacterial culture being used per 100 cc of mash. The fermentations were carried out aërobically at 37° C. In order to minimize any loss of solvents through evaporation, the mouths of the flasks or bottles used in the fermentation experiments were covered with cellophane tied with rubber bands.

Analytical methods.—The total acidity is expressed in terms of the number of cc of 0.1 normal sodium hydroxide solution required to neutralize 10 cc of the medium, with phenolphthalein as indicator. The acetone was determined according to Goodwin's(3) modification of Messinger's method, and the normal butyl and ethyl alcohols according to the oxidation methods of Christensen and Fulmer.(1)

The solvent yields are given either in grams per 100 cc of culture or in terms of the dextrose equivalent of the total carbohydrate in the medium. In the latter case the following calculation will serve as an example: When 5 grams of solvents were obtained from a medium with a total carbohydrate content equivalent to 20 grams of dextrose, the yield was 25 per cent.

EXPERIMENTAL

Fermentation of mashes supplemented with corn meal.—Our early experiments demonstrated that mashes prepared from either cassava or molasses alone cannot support healthy bacterial growth, due to lack of adequate nutrients. For this reason it was necessary to supplement them with materials that are known to be rich in nutrients. In one series of tests patterned after those of Underkofler, Christensen, and Fulmer,(7) the mashes were mixed with varying amounts of corn mash, the object being to determine the maximum quantity of cassava or molasses that can be utilized to substitute the corn meal without lowering the yield of solvents. The results are presented in Table 1.

The data show that cassava can be employed to replace as much as 90 per cent, and molasses only 60 per cent, of the corn meal without diminishing the production of solvents. In other words, the addition of about 0.6 gram of corn meal per 100 cc of cassava mash containing 4 per cent starch will supply sufficient nutrients to support the healthy growth of the acetone butyl alcohol organism. In the case of molasses, about four times as much more corn meal had to be added, but even then the fermentation has not always been satisfactory.

TABLE 1.—*Fermentation of mashes mixed with corn meal.*

Corn meal replaced.	Total solvent yield, per cent of dextrose equivalent.	
	Cassava (gaplex).	Molasses.
Per cent.		
0	35.7	35.4
10	35.1	34.9
20	35.8	35.3
30	36.0	34.8
40	36.0	34.7
50	35.8	35.0
60	36.3	35.3
70	35.9	33.3
80	36.0	28.0
90	35.6	13.3
100	23.8	5.3

Fermentation of mashes supplemented with soybean.—The use of soybean as a source of nutrients was suggested by its high protein content and by the recent work of Weizmann and Rosenfeld,[2](9) who reported that legumes in general are good sources of asparagine and a substance known as "activator," these two compounds, according to the authors, being required for a normal butanol-acetone fermentation. The beans were powdered and mixed with the mashes in varying amounts. The results are given in Table 2.

TABLE 2.—*Fermentation of mashes mixed with soybean.*

Soybean added.	Total solvent yield, per cent of dextrose equivalent.	
	Cassava (gaplex).	Molasses.
g.		
0	18.8	2.9
0.2	33.1	19.4
0.3	34.7	22.3
0.4	36.1	35.3
0.5	36.0	35.2
0.7	36.4	35.6
0.9	36.1	34.9
1.0	36.3	35.5
1.2	35.4	33.4

[2] Later our attention was called to the work of Corbett(2) who utilized mixtures of tungseed meal, soybean and (or) peanut meal for the production of solvents. In some of our experiments we employed powdered mongo seeds in place of the soybean with satisfactory results.

According to the data, at least 0.4 gram of soybean powder is required to furnish the necessary nutrients for the fermentation of both cassava and molasses mashes, the carbohydrate contents of which are equivalent to 4 per cent starch. If more concentrated mashes are to be fermented, the quantity of soybean should be increased in direct proportion to the amount of carbohydrate present to obtain good solvent yields.

Soybean has been found to be a better source of nutrients than corn. It is more economical to use and in our hands it has given more uniformly satisfactory results than corn. The procedure is very simple, and for fermenting molasses it is believed to be less costly than the Arroyo process, even as modified by Owen.(4)

Chemical changes during fermentation.—In this experiment 2,000 cc each of soybean-cassava and soybean-molasses mixtures were placed in a separate flask and sterilized. Immediately after inoculation and at certain intervals thereafter, aliquot portions were removed, with aseptic precautions, for chemical analyses. The object was to determine the duration of the fermentation period and the nature of the chemical changes which take place during the process.

The data presented in Table 3 show that, insofar as the maximum production of solvents is concerned, the fermentation is complete after 69 hours in the case of cassava and after 93 hours in the case of molasses. These figures represent the maximum periods required for the fermentation of these two materials, for in other sets of experiments the fermentations were carried through in much less time. The chemical changes were quite similar to those observed by Peterson and Fred(5) and other investigators during the fermentation of corn; namely, much gas formation, the rapid rise and sudden fall in the acidity of the medium, formation of a "head" due to the buoying up of insoluble particles in the medium by the escaping gas bubbles, the subsequent falling of the "head" to the bottom of the container towards the end of the fermentation and its partial disintegration, the production of solvents, and the secondary rise in the acidity of the medium. The yield of total solvents from either cassava or molasses ranged from 34 to 38 per cent of the dextrose equivalent of the carbohydrate content of the mash and had an average composition of approximately 31 per cent of acetone, 58 per cent of normal butanol, and 11 per cent of ethyl alcohol.

TABLE 3.—*Chemical changes during fermentation.*

Hours after inoculation.	Yield of solvents per 100 cc of medium.									
	Cassava (gaplex).					Molasses.				
	Total acidity.	Acetone.	N-butyl alcohol.	Ethyl alcohol.	Total solvents.	Total acidity.	Acetone.	N-butyl alcohol.	Ethyl alcohol.	Total solvents.
	cc.	*g.*	*g.*	*g.*	*g.*	*cc.*	*g.*	*g.*	*g.*	*g.*
0	0.5	-------	-------	-------	-------	1.6	-------	-------	-------	-------
4	0.7	-------	-------	-------	-------	1.8	-------	-------	-------	-------
21	4.3	0.015	-------	-------	-------	6.8	0.108	0.220	0.030	0.358
28	5.6	0.017	-------	-------	-------	7.0	0.124	0.192	0.055	0.371
44	3.3	0.375	0.733	0.150	1.258	6.4	0.178	0.325	0.089	0.592
50	4.5	0.462	0.843	0.174	1.479	3.7	0.391	0.800	0.126	1.317
69	4.6	0.485	0.952	0.146	1.583	3.2	0.470	0.943	0.148	1.561
93	4.7	0.470	0.904	0.180	1.554	3.5	0.493	0.997	0.179	1.669
117	4.7	0.426	0.912	0.150	1.488	4.5	0.468	0.982	0.147	1.597
140	4.6	0.392	0.887	0.148	1.427	4.4	0.414	0.947	0.133	1.494

Yield of solvents from mashes of different concentrations.— In this experiment mashes of different concentrations were fermented under conditions as uniform as possible for the entire lot. The object was to determine the optimum carbohydrate concentration of the mashes which will give maximum yields of solvents.

The data given in Table 4 show that the highest yields of solvents per sugar unit were obtained from mashes with carbohydrate contents equivalent to between 4.06 and 5.56 grams of dextrose per 100 cc of medium. Of these, mashes 3 to 7, which contained from 4.06 to 5.27 per cent dextrose, gave slightly higher yields per sugar unit than mash 8. The concentration of the solvents in the beers, however, was lower, so that the amount of solvents per 100 cc of medium was actually smaller than that in mash 8. Dilute beers are disadvantageous to handle in the commercial production of solvents, because they necessitate larger distillation space. For this reason it is more economical to work with a more concentrated mash, as represented by mash 8. The latter can be easily prepared from molasses, but unfortunately not from cassava. The most concentrated cassava mash that we have used had a starch content equivalent to 5.23 per cent dextrose. If prepared in more concentrated form, the resulting mash would be too thick in consistency and difficult to handle.

The maximum amount of total solvents obtained from mash 8 was 2.040 grams per 100 cc of medium. Mashes 9 to 13, which

TABLE 4.—*Yields of total solvents from mashes of different concentrations (soybean, being used as the source of nutrients).*

Mash.		Carbohydrate content as dextrose per 100 cc of medium.	Total solvent yield.	
Number.	Constituent.		Grams per 100 cc of medium.	Dextrose equivalent.
		g.		*Per cent.*
1	molasses	3.50	1.240	35.4
2	do.	3.72	1.351	36.3
3	do.	4.06	1.508	37.1
4	do.	4.36	1.614	37.0
5	do.	4.65	1.723	37.0
6	do.	5.02	1.849	36.8
7	do.	5.27	1.969	37.4
8	do.	5.56	2.040	36.7
9	do.	5.87	1.984	33.8
10	do.	6.16	2.032	33.0
11	do.	6.61	1.900	28.7
12	do.	7.27	1.899	26.1
13	do.	7.93	2.035	25.6
14	gaplex	3.38	1.267	37.5
15	do.	3.80	1.429	37.6
16	do.	4.36	1.650	37.8
17	do.	4.79	1.817	38.0
18	do.	5.23	1.966	37.6

had sugar contents higher than 5.56 per cent, did not yield larger amounts of solvents, probably due to the inability of the vegetative phase of the butyl organism to withstand the presence of solvents in quantities much greater than 2 grams per 100 cc of medium. In other words, the fermentation process stops when the concentration of the fermentation products in the mash has reached a certain limit.

SUMMARY AND CONCLUSIONS

1. A strain of *Clostridium acetobutylicum* (Weizmann), which was isolated from rice field soil, was used as the fermenting agent.

2. Mashes prepared from either cassava or molasses alone cannot maintain the normal growth of the acetone-butyl alcohol organism, due to lack of adequate nutrients. For this reason it is necessary to supplement them with materials, such as corn meal or soybean powder, which are rich in nutrients.

3. Soy bean is better than corn as a source of nutrients. The addition of at least 0.4 gram of soybean powder to every 100 cc of mash with a carbohydrate content equivalent to 4 per cent starch will furnish the necessary nutrients for the fermentation of either cassava or molasses. The procedure is simple

and is believed to possess a slight advantage over the Arroyo process for the production of solvents from molasses.

4. The ability of *Clostridium acetobutylicum* to utilize cassava and molasses can be increased by gradually acclimatizing it to grow in the presence of these substances through repeated subculturing, sporulation, and heat-shocking.

5. With the use of derived cultures, the fermentations are complete after a period not exceeding 69 hours in the case of cassava-soybean mixtures and 93 hours in the case of molasses-soybean mixtures.

6. The yield of total solvents is from 34 to 38 per cent of the dextrose equivalent of the carbohydrate content of the mash and has an average composition of approximately 31 per cent acetone, 58 per cent normal butanol, and 11 per cent ethyl alcohol. The average yield from 1 kilo of cassava (gaplex) is 0.8 lb. and from 1 gallon of molasses 2.5 lbs. of total solvents.

7. Mashes with carbohydrate contents equivalent to between 4.06 to 5.56 grams of dextrose per 100 cc of mash give the highest yields of solvents per sugar unit. At the optimum sugar concentration of 5.56 per cent, the maximum yield is 2.040 grams of total solvents per 100 cc of mash. Mashes with higher carbohydrate contents do not yield larger amounts of solvents, due probably to the inability of the vegetative phase of the butyl organism to withstand the presence of solvents at higher concentrations.

LITERATURE CITED

1. CHRISTENSEN, L. M., and E. I. FULMER. Analysis of n-butanol, acetone and ethanol in aqueous solution. Ind. Eng. Chem. Anal. ed. 7 (1935) 180–182.
2. CORBETT, E. G. Butyl and ethyl alcohols and acetone. Australian patent 23,456/35, Aug. 27, 1936.
3. GOODWIN, L. F. The analysis of acetone by Messinger's method. Journ. Amer. Chem. Soc. 42 (1920) 39–45.
4. OWEN, W. L. Blackstrap molasses as raw material for biochemical industries. II. Butanol and acetone. Facts About Sugar 31 (1936) 214, 215, 217.
5. PETERSON, W. H., and E. B. FRED. Butyl-acetone fermentation of corn meal. Ind. Eng. Chem. 24 (1932) 237–242.
6. SMYTH, H. F., and W. L. OBOLD. Industrial Microbiology. Baltimore, The Williams and Wilkins Company (1930) x + 313 pp.
7. UNDERKOFLER, L. A., L. M. CHRISTENSEN, and E. I. FULMER. Butyl-acetonic fermentation of xylose and other sugars. Ing. Eng. Chem. 28 (1936) 350–354.

8. UNDERKOFLER, L. A., E. I. FULMER, and M. M. RAYMAN. Oat hull utilization by fermentation. Ind. Eng. Chem. **29** (1937) 1290–1292.
9. WEIZMANN, C., and B. ROSENFELD. The activation of the butanol-acetone fermentation of carbohydrates by Clostridium acetobutylicum (Weizmann). Biochem. Journ. **31** (1937) 619–639.
10. WEYER, E., and L. F. RETTGER. A comparative study of six different strains of the organism commonly concerned in large-scale production of butyl alcohol and acetone by the biological process. Journ. Bact. **14** (1927) 399–424.

PHOSPHORUS STUDIES ON PHILIPPINE SOILS, I

THE READILY AVAILABLE PHOSPHORUS OF SOILS AS DETERMINED BY THE TRUOG METHOD [1]

By RICARDO T. MARFORI [2]

Of the Division of Soil Survey, Department of Agriculture and Commerce Manila

Various rapid chemical tests that are a distinct aid in ascertaining the state of fertility of soils have been developed in different parts of the world. But the wide variation in soils, climate, and other crop requirements limits the application of such rapid tests to regions or localities where these tests have been well standardized against field results. No single test that has proven useful in estimating the fertilizer requirements of certain crops in a certain region can claim reliability for all crops in all kinds of soils.(13)

Harper(6) reported that the Truog method(15) for determining the easily soluble phosphorus content of soils gave a fairly good correlation with the response of eight farm crops to phosphorus fertilization on eighty-three soils from different parts of the United States.

Sadasivan and Sreenivasan(12) found that among well-known methods of determining phosphate availability in soils, the Truog method gave the highest percentage of extraction of soluble phosphate added to a certain Indian rice clay soil. The other extractants used in comparison with Truog's 0.002*N* sulphuric acid were: Dyer's 1 per cent citric acid, Frap's 0.2*N* nitric acid, Das's 1 per cent potassium carbonate, and Egner's calcium lactate-hydrochloric acid.

Anderson and Noble,(1) in comparing various quick chemical tests as employed independently by two analysts on different

[1] Read at the Fifth Philippine Science Convention, Manila, February 22, 1939.

[2] The writer wishes to express his appreciation of the helpful suggestions and criticisms given by Dr. Marcos M. Alicante, Chief of the Division of Soil Survey. Acknowledgment is also made of the writer's indebtedness to Mr. Rufino Isidro, of the same Division, in charge of the field experiments, for supplying the soil samples and the field data from the rice fertilizer experiments.

soils, found that the personal factor which caused poor agreement in results was greater in some cases than in others. Of the ten different procedures used for phosphorus availability, namely, the Simplex, the Emerson, the Sudbury, the Lamotte, the Hellige, the Indiana, the Hi-Lo-Fosfate, the Morgan, the Truog, and the alkaline-extraction methods, the Truog method was the only one that was not affected appreciably by the personal factor.

Several other investigators (4, 5, 7, 9, 11, et al.) working on the availability of phosphorus in soils in different parts of the United States have used the Truog test and obtained satisfactory results with it.

In view of this apparent accuracy and usefulness of the Truog test, it was considered worth applying on Philippine soils in which there is an imperative need for well-standardized rapid chemical tests as an aid in determining their fertilizer requirements.

EXPERIMENTAL

In this investigation the Truog test was carried out on composite soil samples from the experimental plots of several fertilizer experiments on rice, conducted in different provinces of Luzon. The object was to compare the response of rice to phosphatic fertilization or the field behavior of the soil, and the readily available phosphorus content of the soil on which the crop was grown.

The soil samples from the experimental plots were also analyzed for their pH values, total iron and aluminum oxides, calcium oxides, and phosphoric anhydride contents, to find if there is any relation between the chemical composition of soil and its readily available phosphorus content.

The reaction or the pH value of the soil must be known before the test is made, because the Truog method or any other method that makes use of an acid extractant does not apply to calcareous soils. The findings of Harper, Heck, Ford, and many other investigators show that the relative abundance of iron, aluminum, and calcium in the soil greatly affect the availability or solubility of soil phosphorus.

Four representative samples of each of different soil types where rice is grown were analyzed for their pH values, total CaO, total P_2O_5, and available phosphorus contents, for additional data on the relationship of the composition of the soil to its available phosphorus content. Reputedly fertile virgin

soils from different places in the Islands were also analyzed for comparison.

The method for determining the readily available phosphorus of soils as recommended by Truog was used with certain modifications. For a detailed discussion of the method the reader is referred to the paper of Truog and Meyer.(16) Briefly, the procedure employed in this investigation was as follows:

Two grams of the finely ground soil, passing a sieve with circular openings 0.5 mm in diameter, and 400 cc of 0.002*N* sulfuric acid, buffered to pH 3 with $(NH_4)_2SO_4$, were placed in a 750-ml Erlenmeyer flask and shaken intermittently for 30 minutes, with a total period of 15 minutes of actual shaking. After filtration, 50 cc of the clear filtrate were placed in a 200-cc Erlenmeyer flask. Two cc of ammonium molybdate-sulfuric acid solution were added, and the flask well shaken. Three drops of stannous chloride solution were then added, the flask again well shaken, and the resulting solution compared with a standard phosphate solution similarly treated. The comparison was made within a few minutes by the use of a Bausch and Lomb colorimeter, as the blue color of the reaction begins to fade after about 10 minutes. The results were then computed in parts of available phosphorus per million of oven-dry soil.

Because the method of shaking influences the amount of phosphate dissolved from soil by water, as reported by Hibbard,(8) the shaking of the samples, which was done by hand in this preliminary study, was done as uniformly as possible in all the determinations.

The pH values were determined by the use of the antimony and the glass electrodes. The chemical analyses for the other constituents were made according to the methods of the Association of Official Agricultural Chemists.(2)

RESULTS AND DISCUSSION

Table 1 shows the response of rice to phosphatic fertilization and the readily available phosphorus content of the soils on which the experiments were conducted. Since the soil samples were obtained after the harvest, the readily available phosphorus contents of the control plots might serve as those of the fertilized plots before treatment. Comparison may then be made on this basis.

TABLE 1.—*Response of rice to phosphatic fertilization and the influence of the readily available phosphorus content of soil on yield.*

Soil Lab. No.	Soil.		Treatment (fertilizer formula).[a]	Average yield.	Increase in yield due to phosphatic fertilizer.	Available phosphorus.
	Source.	Type.				
				Cavans per Ha.	*Cavans per Ha.*	*P.p.m.*
E-22	Muñoz, Nueva Ecija	Maligaya silt loam	Control	22.2		3.4
E-23	do.	do.	20-0-0	23.1		3.6
E-24	do.	do.	20-20-0	38.9	15.8	7.8
E-31	Naic, Cavite	Guadalupe clay	Control	24.6		6.4
E-32	do.	do.	20-0-0	39.3		6.5
E-33	do.	do.	20-20-0	55.2	15.9	6.6
E-34	Tanza, Cavite	do.	Control	25.5		8.6
E-35	do.	do.	20-0-0	40.4		7.4
E-36	do.	do.	20-20-0	52.1	11.7	8.4
E-28	Tarlac, Tarlac	Luisita fine sandy loam	Control	27.8		25.6
E-29	do.	do.	20-0-0	35.5		27.7
E-30	do.	do.	20-20-0	56.9	21.4	28.8
E-25	San Manuel, Tarlac	San Manuel silt loam	Control	61.3		37.3
E-26	do.	do.	20-0-0	62.1		41.6
E-27	do.	do.	20-20-0	65.6	3.5	49.2

[a] The rate of application of fertilizer was 150 kilograms per hectare.

Table 1 shows that where the readily available phosphorus content was quite low, let us say, below 37.3 p.p.m., the increase in yield due to phosphatic fertilizer was relatively large compared with the increase in yield of soils quite high in available phosphorus, showing a positive correlation between crop response and the readily available phosphorus content of soils. If this relationship were inversely proportional, one would expect that the lower the available phosphorus content, the greater the increase in yield due to phosphatic fertilization of the soil. Table 1 shows that this would have been the case had not the soil from the fertilizer experiments in Tarlac, Tarlac Province (E28 to E30), given the highest increase in yield, although its initial readily available phosphorus content (E28) was not the lowest.

Another significant fact that one may get from the results of these experiments is that the addition of phosphatic fertilizers did not materially increase the readily available phosphorus content of all the soils except that of San Manuel, Tarlac Province (E25 to E27), which had the highest initial available phosphorus content. This fact may be explained by an investigation of the phosphorus-fixing power or capacity of the soils involved, which will be the subject of the next study. We may say here that,

because the soil from San Manuel, Tarlac Province, had a fairly high available phosphorus content (E25 to E27), its phosphorus-fixing capacity was low, as evidenced by the increase in readily available phosphorus content from 37.3 p.p.m. in E25 to 49.2 p.p.m. in E27.

The data on readily available phosphorus as checked by crop response to fertilization are, as yet, very meager, but more of these will be presented later, when the results of many more fertilizer experiments on rice, still in progress at the time of the writing of this report, are received by the writer.

For comparison, the results of other investigators on this subject in other countries, principally the United States, are presented here. As cited by Truog, McGeorge,(10) using 1 per cent citric acid for the extraction of Hawaiian sugar-cane soils, found the minimum limit of readily available phosphorus for good sugar-cane production to be approximately 17.5 p.p.m.; Dyer,(3) proposing the 1 per cent citric-acid method, set the minimum limit at approximately 44 p.p.m.; and Stoddart,(14) working with the N/5 nitric-acid method, set the limit at 66 p.p.m.

Using his method, Truog tentatively set the minimum limit of readily available phosphorus, for general farming under Wisconsin conditions, at 37.5 p.p.m. for the heavier, better soils, and at 25 p.p.m. for very sandy soils. He explained that

> Crops with a long growing period can get along with a lower supply than those with a shorter growing period, because the long growing period makes possible the utilization of a greater amount of the difficultly available phosphorus. A climate which makes possible a long growing period has a similar effect. As a consequence, fairly good crops of corn can apparently be produced in the South on soils whose readily available phosphorus supply would be entirely inadequate in the North.

Because of the various factors involved, such as crop requirement, climatic conditions, and type of soil, Truog suggested that for certain sections in the southern part of the United States, 10 to 15 p.p.m. of readily available phosphorus might suffice for a good crop of corn.

Harper found that of eighty-three soils with eight farm crops studied, very few soils produced a marked response from phosphorus fertilization when the easily soluble phosphorus was above 20 p.p.m. as determined by the Truog method.

According to Whitney and Gardner,(18) for calcareous soils, by their potassium carbonate extraction method, approximately

37 p.p.m. of available phosphorus may be regarded as the minimum for good crop production.

Table 2 gives the relation of the chemical composition of the soils from the rice fertilizer experiments to their readily available phosphorus contents. The results show that there was no significant variation in the pH values of the soil samples that could be correlated with the variation in easily available phosphorus contents. All the pH values obtained were within the soil reaction tolerance limit for rice, which is from pH 4.8 to pH 6.9 as reported by Weir.(17) Most of the pH values obtained were even within the optimum range of soil reaction for rice, which is from pH 5.5 to pH 6.1 as reported by the same author. But the determination of pH value was made on all the other soil samples just the same, because that was necessary for distinguishing a calcareous soil from a noncalcareous soil. As has been stated before, the Truog test applies only to noncalcareous soils.

TABLE 2.—*Relation of the chemical composition of soil to its readily available phosphorus content.*

Soil Lab. No.	pH value.	Fe_2O_3 and Al_2O_3.	Lime (CaO).	Phosphoric anhydride (P_2O_5).	Available phosphorus.
		Per cent.	*Per cent.*	*Per cent.*	*P. p. m.*
E-22	6.20	28.55	1.92	0.13	3.4
E-23	6.05	27.41	1.91	0.13	3.6
E-24	5.92	27.27	1.81	0.14	7.8
E-31	6.30	30.47	2.14	0.12	6.4
E-32	6.12	30.62	2.05	0.13	6.5
E-33	6.10	30.14	2.01	0.11	6.6
E-34	6.22	31.83	2.09	0.16	8.6
E-35	5.90	31.91	2.16	0.12	7.4
E-36	6.00	30.65	2.00	0.11	8.4
E-28	5.55	26.04	5.37	0.11	25.6
E-29	5.40	26.08	5.50	0.15	27.7
E-30	5.60	26.27	6.03	0.18	28.8
E-25	5.86	28.69	3.33	0.26	37.3
E-26	5.72	28.95	3.45	0.27	41.6
E-27	5.75	27.39	3.61	0.26	49.2

Ford and Heck, who made intensive studies on the subject of phosphate fixation in soils, showed that the presence of relatively large amounts of soluble or active calcium, iron, and aluminum compounds in the soil measures the chemical fixation of phosphorus in soils, which in turn limits the availability of soil phosphorus to plants. According to Heck, with sufficient active calcium and relatively small amounts of active iron and

aluminum in the soil, most of the phosphorus is fixed as tricalcium phosphate, which is slightly soluble in water but easily soluble in dilute acids and, therefore, readily available for plant growth. When active calcium is relatively low, and active iron and aluminum are relatively high in amount, phosphorus is fixed for the most part as difficultly available, except when the predominating compound formed is normal $AlPO_4$ which is moderately soluble in dilute acid solutions and, therefore, moderately available to plants. But fixation in the form of normal $AlPO_4$ generally takes place in very acid soils. When phosphorus is fixed as normal iron phosphate ($FePO_4$), as basic iron phosphate ($Fe_2(OH)_3PO_4$), or as basic aluminum phosphate ($Al_2(OH)_3PO_4$), its availability is very low.

Table 2 shows that there was not much variation in the iron and aluminum oxide contents of the soil samples from the rice fertilizer experiments. Soil sample E27 had 27.39 per cent of Fe_2O_3 and Al_2O_3, and soil sample E23 had 27.41 per cent of the same constituents, yet their readily available phosphorus contents differed greatly, showing that in this group of soils the Fe_2O_3 and Al_2O_3 contents did not constitute a factor in the availability of phosphorus.

The lime and phosphoric anhydride contents of the soil samples from the fertilizer experiments seemed to give a positive correlation with the available phosphorus contents. The groups or sets of samples E22 to E24, E31 to E33, and E34 to E36 had about the same amounts of lime content, around 2 per cent, while samples E28 to E30 had an average of about 5.5 per cent lime. Although their total P_2O_5 contents did not vary much, around 0.12 to 0.15 per cent on the average, their available phosphorus contents differed greatly. The relatively high available phosphorus content of one group was about three times the low available phosphorus content of each of the other groups. This shows that, with the total P_2O_5 contents remaining at about the same level, the higher the CaO content, the higher was the available phosphorus content of the soil.

Comparing soil samples E28 to E30 with samples E25 to E27 we find that both groups had relatively high CaO contents. The two groups differed in their total P_2O_5 contents, and the samples that had higher total P_2O_5 contents had higher available phosphorus contents.

Table 3 gives the average chemical analyses of some Philippine rice soils, and of some reputedly fertile virgin soils. Just

like the results presented in Table 2, the results given in Table 3 are arranged in the order of increasing readily available phosphorus contents, with the unclassified virgin soils grouped separately.

TABLE 3.—*Average chemical analyses of some Philippine rice soils and of some reputedly fertile virgin soils.*

Source (Province).	Type.	pH value.	Lime (CaO).	Phosphoric anhydride (P_2O_5).	Available phosphorus.
			Per cent.	*Per cent.*	*P.p.m.*
Rizal	Novaliches clay loam adobe	5.50	1.46	0.12	5.8
Pangasinan	Alaminos loam	6.04	1.24	0.09	6.9
Bulacan	Novaliches loam	5.95	1.06	0.12	10.4
Cavite	Guadalupe clay	6.66	2.33	0.19	10.7
Do	Tagaytay loam	5.92	1.76	0.27	12.4
Pangasinan	Bani clay	6.56	3.20	0.10	14.2
Nueva Ecija	Quingua silt loam	6.61	3.50	0.21	32.1
Ilocos Sur	Baybay sandy loam	6.64	4.85	0.18	32.8
Tarlac	Luisita fine sandy loam	6.12	5.17	0.15	39.2
Ilocos Sur	Sevilla clay loam	6.72	3.41	0.16	41.9
Tarlac	La Paz fine sandy loam	6.04	4.13	0.13	44.6
La Union	Baybay clay loam	6.68	3.48	0.26	45.8
Tarlac	San Manuel silt loam	6.02	3.84	0.16	47.4
Nueva Ecija	Bantog clay loam	6.42	2.43	0.22	48.0
Ilocos Sur	Baybay clay loam, deep phase	6.65	3.83	0.32	64.5
UNCLASSIFIED VIRGIN SOILS					
Tayabas (Mount Banahao)		5.21	1.42	0.48	20.7
Davao (Mount Apo)		5.14	1.30	0.41	21.5
Tayabas (Mount San Cristobal)		5.64	4.20	0.46	28.7
Cotabato (Koronadal Valley)		6.18	4.63	0.26	64.7

In Table 3 we can see that again there was not much variation in the pH values of the different soil types which were under cultivation. However, it may be pointed out that, with the virgin soils studied, there seemed to be a positive correlation between pH values, CaO contents, and readily available phosphorus contents, although the variations in pH values were slight.

With the chemical composition of the different rice soils presented in Table 3, there was the same apparent positive correlation between CaO and readily available phosphorus contents, as that which existed among the results presented in Table 2. Beginning with the Quingua silt loam, which had an available phosphorus content of 32.1 p.p.m., all, with the ex-

ception of one (Bantog clay loam which had 2.43 per cent CaO), had relatively high CaO contents, above 3.41 per cent, and high available phosphorus contents, up to 64.5 p.p.m., which was that for Baybay clay loam, deep phase. In the case of the Bantog clay loam we might say that its fairly high total P_2O_5 content, 0.22 per cent, with a total CaO content not so low, gave it a fairly high available phosphorus content.

In the case of the virgin mountain soils, although the total P_2O_5 content was fairly high, the available phosphorus content was relatively low. The fairly low CaO contents of the Mount Banahao and the Mount Apo soils, 1.42 per cent and 1.30 per cent, respectively, might account for this. But what was more probable as the chief cause of this condition was that all these virgin mountain soils had very high organic matter contents (as shown by chemical analyses not included in this report) which held most of the phosphorus not in the available form. But through microbial or biological activities the phosphorus held in the organic matter portion of the soil gradually became available for plant growth.

SUMMARY

The Truog test for determining the readily available phosphorus of soils was made on soils where fertilizer experiments on rice were conducted. The meager results show that there was a positive correlation between crop response to phosphatic fertilization and the amount of readily available phosphorus in the soil; the lower the available phosphorus content of the soil, the greater was the increase in yield due to phosphatic fertilization, with one exception.

Ninety soil samples from different parts of the Philippines, but mostly rice soils of Luzon, have been analyzed according to the Truog method. For some Philippine soil types, at least, 30 to 40 p.p.m. of available phosphorus may not be far from the minimum limit of available phosphorus that will suffice for a good crop of rice.

The results seem to indicate that, with the total P_2O_5 content of the soil remaining constant, the higher the CaO content, the higher was the readily available phosphorus content; and that, with the CaO content of the soil remaining constant, the higher the total P_2O_5 content, the higher was the readily available phosphorus content. Exceptions to these findings were virgin soils very rich in organic matter.

LITERATURE CITED

1. ANDERSON, M. S., and W. M. NOBLE. Comparison of various chemical quick tests on different soils. U. S. Dept. Agri. Misc. Pub. 259 (1937) 1–24.

2. Association of Official Agricultural Chemists. Official and tentative methods of analysis. Assoc. Off. Agri. Chemists. Washington, D. C. 4th ed. (1935) 1–710.

3. DYER, B. On the analytical determination of the probably available plant food in soils. Trans. Chem. Soc. 65 (1894) 115–167. Cited by Truog.(15)

4. FORD, M. C. The distribution, availability, and nature of the phosphates in certain Kentucky soils. Journ. Amer. Soc. Agron. 24 (1932) 395–410.

5. FORD, M. C. The nature of phosphate fixation in soils. Journ. Amer. Soc. Agron. 25 (1933) 134–144.

6. HARPER, HORACE J. The easily soluble phosphorus content of soil as determined by electrodialysis, extraction with dilute acid solutions, and crop response to fertilization. Soil Sci. 35 (1933) 1–16.

7. HECK, A. FLOYD. Phosphate fixation and penetration in soils. Soil Sci. 37 (1934) 343–355.

8. HIBBARD, P. L. Influence of method of shaking on amount of phosphate dissolved from soil by water. Science 75 (1932) 464–465.

9. HIBBARD, P. L. Estimation of plant available phosphate in soil. Soil Sci. 35 (1933) 17–28.

10. MCGEORGE, W. T. A study of the phosphates in the Island sugar lands. Hawaiian Sugar Planters' Assoc. Exp. Sta. Bull. 47 (1923). Cited by Truog.(15)

11. ROST, C. O., and R. M. PINCKNEY. Colorimetric methods for the determination of readily available phosphorus in soils. Journ. Amer. Soc. Agron. 24 (1932) 377–395.

12. SADASIVAN, V., and A. SREENIVASAN. On chemical methods of determining phosphorus availability in soils. Journ. Indian Institute of Sci. 20 A (1937) 67–81.

13. SCHREINER, OSWALD, and M. S. ANDERSON. Determining the fertilizer requirements of soils. U. S. Dept. Agri. Yearbook of Agriculture 1938 (1938) 469–486.

14. STODDART, C. W. Soil acidity in its relation to lack of available phosphates. Journ. Indus. and Engin. Chem. Ed. 1 (1909) 69–74. Cited by Truog.(15)

15. TRUOG, EMIL. The determination of the readily available phosphorus of soils. Journ. Amer. Soc. Agron. 22 (1930) 874–882.

16. TRUOG, EMIL, and A. H. MEYER. Improvements in the Denigés colorimetric method for phosphorus and arsenic. Indus. and Engin. Chem. Analyt. ed. 1 (1929) 136–139.

17. WEIR, WILBERT WALTER. Soil science, its principles and practice. Chicago and Philadelphia. J. B. Lippincott Co. (1936) 1–615.

18. WHITNEY, R. S., and R. GARDNER. Notes on estimating available phosphorus by extracting soils with potassium carbonate solution. Soil Sci. 41 (1936) 33, 34.

DECOLORIZING CARBON AND SODIUM SILICATE FROM PHILIPPINE CARBONACEOUS RICE-HULL ASH

By Aurelio O. Cruz and Augustus P. West
Of the Bureau of Science, Manila

Rice hulls are light in weight, neutral in odor, and have a slow combustibility. They are used for packing hygroscopic materials to prevent moisture absorption; for filtering and percolating; for insulation, the making of insect powder, and for various other purposes.

Burnt rice hulls have been suggested as raw material for making decolorizing carbon and sodium silicate (water glass).[1]

In the Philippines rice hulls usually serve as fuel in the rice mills. The black carbonaceous ash that remains after burning the hulls is now discarded as waste. If this carbonaceous ash can be profitably converted into decolorizing carbon and sodium silicate a new local industry can be established. Decolorizing carbon is used locally for refining sugar, and sodium silicate is employed in soap manufacture. Both of these products are also used industrially for numerous other purposes.

This paper is a continuation of our work on Philippine rice-mill products. It suggests new industries that may be developed in the Philippines from the byproducts of rice mills. In our first publication[2] we gave the results of our investigations on the nutritive value and preservation of rice bran and on the products that may be made from the bran. This report gives an account of our procedure for making, in one process, both decolorizing carbon and sodium silicate (water glass) from the carbonaceous ash obtained by burning Philippine rice hulls.

[1] Zerban, F. W., Louisiana Agr. Exp. Sta. Bull. No. 161 (1918).
Zerban, F. W., E. C. Freeland, and D. D. Sullivant, Louisiana Agr. Exp. Sta. Bull. No. 167 (1919).
Gambel, C. J., Chem. Abs. 19 (1925) 1477 and 2730.
Shilstone, H. M., Chem. Abs. 19 (1925) 3571.
Bladone, G., Chem. Abs. 13 (1919) 1132.

[2] West, A. P., and A. O. Cruz, Philip. Journ. Sci. 52 (1933) 1.

It would seem advisable for the Government to establish, in or near Manila, a rice mill to be operated scientifically for the production of rice and rice-mill byproducts. The byproducts will then be used as raw materials for making new things for which there is a demand. These new commodities will be processed in pilot plants to ascertain if it is feasible to produce them on a commercial scale. The polished rice that is milled could be sold to the Army to defray the expenses of operating the mill.

When paddy rice (palay) is milled in the Philippines for the preparation of white rice the byproducts are rice bran and rice hulls. The estimated yearly production of Philippine rice hulls is 567,342 tons.[3] A factory located near a rice-milling district would have an available supply of rice hulls from which industrial products may be made.

In Table 1 is given the analysis of rice hulls from two varieties of Philippine rice (ramai and macan).[4]

TABLE 1.—*Analysis of Philippine rice hulls.*

Constituent.	Variety of rice hulls.	
	Ramai.	Macan.
	Per cent.	*Per cent.*
Moisture	7.65	6.77
Fat (ether extract)	0.62	0.63
Protein	1.75	1.97
Crude fiber	34.97	38.92
Ash	22.29	21.69
Carbohydrates by difference	32.72	30.02
Total	100.00	100.00

As shown in Table 1, the hulls consist largely of crude fiber and also have a rather high ash content. According to Harding [5] the crude fiber yields a very pure cellulose. This substance serves as raw material for making numerous commercial products, such as paper, rayon, cellophane, and lacquers.

[3] Tom. cit., p. 19.
[4] Tom. cit., p. 21.
[5] Journ. Indus. Eng. Chem. 20 (1928) 310.

According to a recent announcement,[6] rayon made from the alpha cellulose of rice hulls is one of the latest Japanese industries:

> A $2,900,000 industry is being promoted in Tokyo with the object of producing rayon-making pulp from rice hulls, of which a practically unlimited supply is assured in Japan.
>
> The process which forms the basis of the new industry has been developed by the Tokyo Industrial Laboratory, a division of the Department of Commerce and Industry, in collaboration with the research institute of the South Manchuria Railway Company.
>
> Because Japan depends on imports for 250,000 out of 300,000 tons of rayon pulp annually consumed by the artificial silk industry, the supply of raw material from an entirely new source is expected considerably to benefit the textile industry as well as the farmers who are hard put to make a living from their scanty acres.
>
> Japan at present is among the world leaders in the production of rayon yarn. And Japan is the world's first rice grower. The annual crop averages 475 million bushels.

Rice hulls also contain pentosans which may be converted into furfural. This substance is used in making various kinds of synthetic resins.

When rice hulls are burned thoroughly so as to eliminate combustible carbonaceous matter, the ash that remains has a slightly grayish color and consists almost entirely of silica, as shown by our analysis (Table 2). On account of the high silica content this rice-hull ash, finely powdered, serves as a good polishing powder. It can also be employed in making polishing pastes and scouring soaps, and can serve as an ingredient in the manufacture of glass.

TABLE 2.—*Analysis of Philippine rice-hull ash, free of combustible carbonaceous matter.*

Constituent.	Per cent.
Silica oxide	95.38
Iron and alumina oxides	0.42
Calcium oxide	0.20
Magnesium oxide	0.52
Phosphorus as P_2O_5	0.57
Sodium and potassium oxides	2.20
Total	99.29

When rice hulls are burned as fuel in Philippine rice mills, the residue is usually a black carbonaceous ash. The carbon

[6] Science News Letter 32 No. 854 (1937) 120.

content of the ash depends upon the temperature of heating and the length of time the hulls are allowed to remain in the furnace.

In Table 3 is given the carbon content of eight samples of carbonaceous rice-hull ash obtained from the same rice mill. The percentage of carbon was determined by heating a weighed portion of the moisture-free ash in a muffle furnace to constant weight. As shown by the data the carbon content varied from 11.8 to 30.8 per cent, which shows that the rice hulls were not always burned under the same conditions.

TABLE 3.—*Carbon content of carbonaceous rice-hull ash.*

Sample.	Carbon. Per cent.
1	11.8
2	15.6
3	16.3
4	18.0
5	19.4
6	23.4
7	26.4
8	30.8

Based upon the analysis of rice-hull ash free of combustible carbonaceous matter (Table 2), the composition of rice-hull ash having different amounts of carbon was calculated. The results for samples containing 11.8, 18, 23.4 and 30.8 per cent carbon are presented in Table 4.

Ash, free of combustible carbonaceous matter, gave a total analysis (Table 2) of 99.29 per cent and a silica content of 95.38 per cent. If the ash contains 11.80 per cent carbon (Table 4, sample 1) then the silica content is calculated as shown below:

$$99.29 - 11.80 = 87.49$$
$$99.29 : 87.49 = 95.38 : X$$
$$X = 84.04\% \text{ silica}$$

The percentages of the other constituents (Table 4) were calculated in like manner.

The black carbonaceous ash obtained when rice hulls are burned as fuel consists mostly of silica and carbon (Table 4). Apparently this ash is similar to the silica black that Jacobson[7] prepared by heating a mixture of finely divided coal and siliceous material (diatomite). Concerning silica black Jacobson says:

This black powder could not be separated into dark and light components like the original products by employing either air, water, or

[7] Journ. Indus. Eng. Chem. 26 (1934) 798.

TABLE 4.—*Composition of carbonaceous rice-hull ash containing different amounts of carbon.*[a]

Constituent.	Sample.			
	1	4	6	8
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Carbon	11.80	18.00	23.40	30.80
Silicon oxide (silica)	84.04	78.09	72.90	65.79
Iron and alumina oxides	0.37	0.34	0.32	0.29
Calcium oxide	0.18	0.16	0.15	0.14
Magnesium oxide	0.46	0.43	0.40	0.36
Phosphorus as P_2O_5	0.50	0.47	0.44	0.39
Sodium and potassium oxides	1.94	1.80	1.68	1.52
Total	99.29	99.29	99.29	99.29

[a] These data were calculated from the analysis of rice-hull ash, free of combustible carbonaceous matter (Table 2).

oil flotation. Neither could white or gray particles be recognized under a magnification of 560 diameters.

The mixture of coal and diatomite had changed into something that was no longer a mechanical mixture. This product the author called "silica black." . . .

This product, when made from coal and diatomite, or coal and precipitated silica, is a black siliceous material containing carbon in different proportions together with 4 to 7 per cent of a nonsiliceous residue composed mainly of iron and aluminum. When the silica black is obtained from coal and talc, however, the nonsiliceous residue amounts to more than 38 per cent.

X-ray photographs indicate that silica black is principally amorphous. However, a trace of a silicon carbide pattern is visible, showing that a small amount of crystalline silicon carbide must be present. The greater part of the carbon in the product is doubtless in the absorbed form, although a certain proportion may be represented as carbides of silicon, iron, and aluminum.

Silica black reduces metallic oxides at high temperatures and is a good agent for clarifying and decolorizing liquids. It also has a high oil absorption. Jacobson suggested various uses for it, such as a pigment for paints and printing inks; a carrier for insecticides and a support for nickel in the hydrogenation process.

A sample of the finest grade (A) of silica black contained 18.14 per cent carbon, 75.56 per cent silica and 6.25 per cent of other constituents. By comparing this grade of silica black with a rice-hull ash having 18 per cent carbon (Table 4) it will be seen that these two products have somewhat the same composition (Table 5).

TABLE 5.—*Comparison of fine-grade silica black with carbonaceous rice-hull ash containing 18 per cent carbon.*

Constituent.	Silica black.	Carbonaceous rice-hull ash.
	Per cent.	*Per cent.*
Carbon	18.14	18.00
Silica	75.56	78.09
Other constituents	6.25	3.20
Total	99.95	99.29

EXPERIMENTAL PROCEDURE

A number of preliminary experiments were carried out to ascertain the best procedure for making in one process both decolorizing carbon and sodium silicate from carbonaceous rice-hull ash. These experiments consisted essentially in treating the ash with different concentrations of sodium hydroxide. Below is given an outline of the method we selected as the most appropriate procedure.

Rice hulls

↓ Used as fuel in rice mills.

Black carbonaceous ash

↓ Dry, grind and sieve (200 mesh). Boil with sodium hydroxide 30° (Baumé) for an hour. Filter.

Filtrate 1 | Residue

Residue ↓ Wash with water and boil again with sodium hydroxide solution 12° Baumé. Filter.

Filtrate 2 | Residue

Filtrate 2 ↓ Combine filtrates 1 and 2 and evaporate to 40° or 60° Baumé.

Sodium silicate (water glass)

Residue ↓ Wash with water, hydrochloric acid, and again with water. Dry at 105° C.

Decolorizing carbon

The carbonaceous ash obtained from the rice mills is first dried at 105° C., because the ash is often piled outside the mill where it is exposed to the weather. It is then ground sufficiently fine to pass a 200 mesh sieve. The dried and finely powdered carbonaceous ash is treated with sodium hydroxide solution having a concentration of 30° Bé. For each kilo of ash 2 liters of the alkali solution are used. The mixture is boiled about an hour to dissolve the soluble silicates after which it is filtered. Filtrate 1 from the carbon residue is set aside for the preparation of sodium silicate.

To remove most of the silicates the carbonaceous residue is washed with hot water. The residue is then placed in a suitable container. It is treated with a liter of sodium hydroxide solution (12° Bé.) After boiling for about one hour the hot solution is filtered. Filtrate 2 is combined with filtrate 1.

The black residue is washed with hot water, then with dilute hydrochloric acid to neutralize the alkali and again with water until the washings are no longer acidic. This decolorizing carbon is finally dried in an oven at 105° C. It is very efficient for decolorizing solutions.

The combined alkaline filtrates 1 and 2 from the carbonaceous ash are evaporated to a thick sirupy liquid (sodium silicate or water glass) having a concentration of 40° Baumé. This concentration is very suitable for sodium silicate intended for use as an ingredient in making soap. When the silicate is to be used as an adhesive or for other purposes the solution is evaporated still further to a concentration of 60° Baumé.

The color of the sodium silicate solution depends upon the kind of carbonaceous ash obtained from the rice hulls. For high-grade sodium silicate an ash containing a relatively small amount of carbon (less than 12 per cent) is preferable to one having a rather large amount, because the first gives a solution that is nearly colorless while the latter produces a yellowish-brown liquid. However, for soap making the colored sodium silicate is very satisfactory and gives a whitish cream-colored soap.

Data on carbonaceous rice-hull ash and the decolorizing carbon and sodium silicate made from it are given in Table 6. As shown by the data, treatment with alkali greatly reduces the ash content of the carbonaceous rice-hull ash by removing a large portion of the silica as soluble silicate which is converted into sodium silicate. The alkali also decomposes

some resinous constituents that are contained in the carbonaceous rice-hull ash. Analysis of the sodium silicate thus prepared is given in Table 11.

TABLE 6.—*Data on carbonaceous rice-hull ash and the decolorizing carbon and sodium silicate made from it.*[a]

Sample.	Carbonaceous rice-hull ash.		Decolorizing carbon.			Sodium silicate concentration, Baumé.[c]	
	Carbon.	Ash.	Carbon.	Ash.	Yield. [b]	40°	60°
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*
3	16.3	83.7	88.2	11.8	168.5	3,815	2,251
5	19.4	80.6	90.0	10.0	195.5	3,758	2,217
6	23.4	76.6	90.3	9.7	252.0	3,721	2,197
7	26.4	73.6	92.3	7.7	270.5	3,513	2,072

[a] The quantity of carbonaceous rice-hull ash used for each sample was 1,000 grams, dry weight.
[b] The yield of sodium silicate is given for a solution of 40° Baumé and also for a more concentrated solution of 60° Baumé.
[c] Analysis of the sodium silicate is given in Table 11.

Decolorizing carbon.—This product is also known as carbon black and as activated carbon. It is ordinarily obtained by the combustion of natural (hydrocarbon) gas or other carbonaceous materials, like nut shells. It is used in making numerous products; such as inks, polishes, pigments, carbon papers, black leather, insulating materials, rubber, gas masks, and for clarifying and decolorizing liquids.

Concerning the purification of water by carbon, Morrison[8] states:

> During the past six years the scope of usefulness of activated carbon has been much enlarged by its introduction into the field of water purification. At the present time between 800 and 1000 water purification plants depend upon activated carbon as the best means of insuring to the public palatable water at all times of the year. It is true that chlorine has for many years provided a germ-free water, but until the advent of activated carbon, many waters—although quite safe for drinking purposes—were at times unpalatable as compared with clear, spring water. The function of powdered, activated carbon is to absorb and remove from the water, impurities contained in the water or resulting from prior chemical treatment of water.

The samples of rice-hull decolorizing carbon recorded in Table 6 were tested in the laboratories of the Insular Sugar Refining Corporation at Mandaluyong, Rizal (near Manila). These tests were made to determine the carbon efficiency for

[8] Man In A Chemical World (1937) 38.

saccharine liquids. A fresh molasses of more than 80° Brix was used as the liquid to be decolorized and the results were recorded according to the Newburgh scale. For comparison these results were checked against the efficiency of a standard carbon and also suchar carbon. The data are recorded in Table 7.

TABLE 7.—*Carbon efficiency of decolorizing carbons.*

Carbon sample.	Carbon efficiency (Newburgh scale).
Standard	100.0
Suchar	165.0
Rice-hull No. 3	127.3
Rice-hull No. 5	127.3
Rice-hull No. 6	175.6
Rice-hull No. 7	83.3

With the exception of sample No. 7 the carbon efficiency of the rice-hull carbons was above the efficiency of the standard carbon. Sample 6 gave even a higher value than the Suchar sample.

The rice-hull decolorizing carbon, sample 7 (containing 92.3 per cent carbon), was obtained from a sample of carbonaceous rice-hull ash that was not burned very thoroughly or uniformly. It contained a quantity of only partly burned rice hulls. When this kind of carbonaceous rice-hull ash is treated with alkali to remove most of the ash the carbon that remains is not of very good quality.

If the furnace in the rice mill is handled properly, with modern temperature control, the rice hulls can very likely be burned uniformly to produce a carbonaceous rice-hull ash from which a good decolorizing carbon can be obtained.

To ascertain the decolorizing (carbon) efficiency of rice-hull carbon for vegetable oils a sample was checked against imported high-grade carbons, coconut oil being used as the liquid to be decolorized. The coconut oil gave an original color reading of 4.5 red and 27 yellow.

In determining the color of the coconut oil both before and after treatment with the decolorizing carbons we used a Wesson model, cabinet-type colorimeter made by the Emil Greiner Company. We also followed the procedure adopted by the Conference of Coconut Oil Manufacturers of the Philippines (1924).

All samples will be read to a yellow base to be determined by adding the two whole red units, within whose limits the sample falls, and multiplying same by 3.

The procedure for decolorizing the oil was as follows:

One hundred cubic centimeters of coconut oil were poured into a 250-cubic-centimeter Erlenmeyer flask. A definite amount of the decolorizing carbon was added. The mixture was placed on a steam bath for 15 minutes and shaken occasionally. It was then filtered several times until the filtrate was entirely clear. The clear oil was then cooled to room temperature and the color determined.

The quantities of decolorizing carbon used varied from 0.5 to 2 grams. The results are recorded in Table 8. As shown by the data these three carbons gave about the same results within experimental error. All of these carbons were thus found to be excellent agents for reducing the color of coconut oil.

TABLE 8.—*Decolorizing efficiency of rice-hull carbon and two imported carbons for decolorizing coconut oil.*[a]

Sample.	Quantity of carbon used for 100 cc coconut oil.	Color of oil.[b]	
		Red.	Yellow.
	Grams.		
Rice-hull carbon	0.5	1.6	9.0
	1.0	1.0	6.0
	1.5	0.6	4.0
	2.0	0.5	3.0
Standard carbon	0.5	1.7	9.0
	1.0	1.0	6.0
	1.5	0.6	4.0
	2.0	0.5	3.0
Suchar	0.5	1.4	9.0
	1.0	0.9	6.0
	1.5	0.5	4.0
	2.0	0.5	3.0

[a] The rice-hull carbon was sample 6 (Table 6) containing 90.3 per cent carbon.
[b] The coconut oil gave an original color reading of 4.5 red and 27 yellow.

The rice-hull carbon used in these color-reduction experiments with coconut oil was made by treating the black carbonaceous ash of rice hulls twice with sodium hydroxide (page 149). To ascertain the advisability of using a cheaper method for preparing the carbon in which less alkali is employed, we treated the carbonaceous rice-hull ash just once with sodium hydroxide (12° Baumé) according to the general procedure outlined on page 148. Data showing the amount of ash removed from the carbonaceous rice-hull ash by this treatment are given in Table 9.

TABLE 9.—*Composition of carbonaceous rice-hull ash before and after treatment with sodium hydroxide (12° Baumé).*

Sample	Carbonaceous rice-hull ash.			
	Before treatment with NaOH (12° Baumé).		After treatment with NaOH (12° Baumé).	
	Carbon.	Ash.	Carbon.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	11.8	88.2	19.9	80.1
2	15.6	84.4	27.7	72.3
5-A	20.3	79.7	37.3	62.7
8	30.8	69.2	57.0	43.0

Treatment with sodium hydroxide (12° Baumé) removed only a small amount of ash from the carbonaceous rice-hull ash. Decolorizing carbon made in this manner contains a large amount of siliceous ash and is not efficient for decolorizing saccharine solutions. It is also not quite as good for reducing the color of coconut oil as the rice-hull carbon made

TABLE 10.—*Decolorizing efficiency of siliceous decolorizing carbons obtained by treating rice-hull ash only once with sodium hydroxide (12° Baumé).*[a]

Sample.	Carbon content of siliceous decolorizing carbon.	Quantity of siliceous decolorizing carbon used for 100 cc of coconut oil.	Color of oil.	
			Red.	Yellow.
		Grams.		
1	19.9	0.5	2.0	12.0
		1.0	1.8	9.0
		1.5	1.2	9.0
		2.0	1.1	9.0
2	27.7	0.5	2.0	12.0
		1.0	1.6	9.0
		1.5	1.1	9.0
		2.0	1.0	6.0
5-A	37.3	0.5	2.0	12.0
		1.0	1.6	9.0
		1.5	1.1	9.0
		2.0	1.0	6.0
8	57.0	0.5	2.0	12.0
		1.0	1.6	9.0
		1.5	1.1	9.0
		2.0	1.0	6.0

[a] Coconut oil was used as the agent to be decolorized. It gave an original color reading of 4 red and 24 yellow.

by treating carbonaceous rice-hull ash twice with sodium hydroxide (page 149). This is shown by comparing the data recorded in Tables 8 and 10.

Siliceous materials, like Fuller's earth, are used for clarifying oils and reducing the color. For ordinary commercial purposes these siliceous rice-hull carbons containing from 27.7 to 57 per cent carbon (Table 9) gave fairly satisfactory results for refining coconut oil. The color of the oil (Table 10) was reduced from a reading of 4 red and 24 yellow to 1 red and 6 yellow.

Sodium silicate (water glass).—Sodium silicate is commonly made by treating sand or other siliceous materials with sodium hydroxide. Sodium silicate has interesting properties which permit its use in various industries, particularly in the manufacture of soap. Aside from the special detergent properties which sodium silicate gives to soaps and washing powders, it has the added value of economy because of its low production cost.

Sodium silicate is used for preserving eggs by making the shells air-tight; as an addition to water to prevent the corrosion of water pipes. It is also employed as an adhesive in making paper boxes; as a binding agent for concrete roads and walls; for briquetting coal; and for other purposes.

Good accounts of the detergency and other properties of sodium silicate are given by Snell[9] and Vail.[10]

TABLE 11.—*Analysis of crude, refined, and imported sodium silicate.*

Constituent.	Sodium silicate, 40° Baumé.		
	Made from rice-hull ash. [a]		Imported.
	Crude. [b]	Refined.	
	Per cent.	*Per cent.*	*Per cent.*
Moisture	68.3	66.3	69.0
Silica	17.9	20.7	20.5
Sodium oxide	12.1	10.4	10.0

[a] The rice-hull ash employed in making the crude and refined sodium silicate contained 23.4 per cent carbon (Table 6).

[b] Commercial sodium hydroxide, which usually contains 1 to 2 per cent of chlorides and other salts, was used in making the crude sodium silicate. This sample of sodium silicate would, therefore, contain some chlorides and small amount of other salts not accounted for in the analysis.

[9] Journ. Ind. Eng. Chem. 25 (1933) 1240.

[10] Op. cit. 27 (1935) 888; 28 (1936) 294.

The composition of sodium silicate varies somewhat according to the method of preparation and the quality of the materials used in making it. As shown by the data, Table 11, the crude sodium silicate made from rice-hull ash, by the procedure given on page 149, contains more sodium oxide (12.1 per cent) than the imported sodium silicate (10 per cent). This kind of sodium silicate is good for making soaps, as the excess alkali aids in saponifying the fat.

For making adhesives and other products the excess alkali is not desirable as it tends to decompose them. By diluting the crude sodium silicate with water until the volume has been increased about 10 per cent and then heating it with rice-hull ash that has been burned until free of carbon, the excess alkali in the crude sodium silicate is neutralized. The refined product thus obtained is then evaporated to 40° Baumé. It has about the same composition as the imported sodium silicate except that it has a little less moisture.

Our analyses (Table 11) of imported sodium silicate and also the crude and refined sodium silicates, prepared from rice-hull ash, were made according to the methods given by Griffin.[11]

SUMMARY

When paddy rice (palay) is milled in the Philippines for the preparation of white rice the byproducts are rice bran and rice hulls. The estimated yearly production of Philippine rice hulls is 567,342 tons.

In the Philippines rice hulls usually serve as fuel in the rice mills. The residue after burning the hulls is generally a carbonaceous ash that has a black color and is now discarded as waste. Apparently this ash is similar to the silica black that Jacobson prepared by heating a mixture of finely divided coal and siliceous material.

This report gives an account of our procedure for making, in one process, both decolorizing carbon and sodium silicate (water glass) from the carbonaceous ash obtained by burning Philippine rice hulls.

Samples of the rice-hull decolorizing carbon gave for saccharine liquids a carbon efficiency greater than that of a standard carbon. One sample was even more efficient than suchar carbon.

[11] Technical Methods of Analysis (1927) 41.

The rice-hull decolorizing carbons were also found to be excellent for reducing the color of coconut oil.

Treatment of the carbonaceous rice-hull ash only once with sodium hydroxide (12° Baumé) gave a very siliceous rice-hull carbon. For ordinary commercial purposes these siliceous rice-hull carbons containing only 27.7 to 57 per cent carbon gave satisfactory results for reducing the color of coconut oil.

Crude sodium silicate, made from carbonaceous rice-hull ash by the method we employed, was found to contain about 2 per cent more alkali than imported sodium silicate. This kind is good for making soaps as the excess alkali aids in saponifying the fat.

By treating the crude sodium silicate with rice-hull ash (carbon free) the excess alkali is neutralized. This refined product had about the same composition as an imported sodium silicate.

FERN EVOLUTION IN ANTARCTICA

By E. B. Copeland
Of Berkeley, California

TWO TEXT FIGURES

This is a study in the reconstruction of the history of ferns by the interpretation of present geographic distribution.

The explanation of the present distribution of plants by their history is one of the comparatively few problems of the systematic botanist that have a wide popular appeal. This explanation is almost too easy, if the geologic history is known, but that is the case with only a small fraction of the living plants. Since what is demonstrably true of some plants of a region may well be true of others, the established history of a small part of the plants of Europe and North America gives us the probable history of a large part of the flora. Thus, if a plant,—say, *Osmunda bipinnata*,—be found now in the eastern United States and in eastern Asia, and its fossils are found in several northern lands, we recognize the present localities as remnants of a once far-northern range around the world, the present discontinuous distribution being the result of extermination by ice throughout the rest of its old range. And if another plant species is found in the same places, but no fossils are known, we do not hesitate to explain the discontinuity in the same manner. If a Japanese plant be nearly related to one of Atlantic North America, instead of being identical with it, the argument is the same; at least one of them has changed somewhat in the course of time.

That is, we construct the history of a plant, or group of plants, by interpreting the present distribution. In the absence of fossils, the argument has to take this direction. We are very familiar with this picture of the history of vegetation in the northern hemisphere. Our common American ferns are the common ferns of Europe, and it seems to us that this could hardly have been otherwise. For, with narrow gaps or none, we know that at a time, very recent, geologically speaking, the continents were connected by land with a climate favorable to our ferns.

We are far less familiar with the idea that any far-southern land might have been the common source of the vegetation of areas now completely disconnected. The comparative paucity of land in the South (text fig. 1), and the present total unfitness of antarctic land for vegetation, have tended to keep us from trying to apply to the South the ideas familiar to us with regard to the North. Still, it is nearly eighty years since J. D. Hooker [1] suggested such an explanation:

> The many bonds of affinity between the three southern Floras, the Antarctic,[2] Australian, and South African, indicate that these may all have been members of one great vegetation, which may once have covered as large a southern area as the European now does a Northern.

The most active exponent of this idea has been Skottsberg, who, in one of several papers on the subject,[3] listed many genera of flowering plants, in 49 families, represented in Antarctic America and New Zealand (or, a few, in Australia). Nearly a score of small families are distributed in a manner inexplicable on any other assumption. The evidence of small families forces itself on us, while we easily overlook that of large genera and families. Thus, in the case of *Grammitis*, with one manifestly Antarctic-bred species, and with about 120 species confined to the Tropics, the probably Antarctic origin of the genus has escaped suspicion; while *Todea*, with one far-southern species and no other species anywhere, has been conspicuous and accepted as strong evidence. A large family, even if of southern origin, cannot possibly be predominantly far-southern in present distribution, because tropical and northern species must outnumber the whole flora of Antarctic America, or even of New Zealand.

Besides vascular plants, the distribution of certain groups of mosses, worms, molluscs, crustaceans, and insects has been interpreted as indicating an origin farther south than where any such organisms now live.

As to the ferns, Christ [4] summed up the evidence to his date, and construed it better than have later writers, content to quote him inperfectly and add nothing:

> Noch bleibt eine hochinteressante Gruppe von Farnen zu erwähnen, welche man in dem Sinn antarktisch nennen kann, als sie zwar nicht boreal-alpin in Charakter, sondern gemässigte bis subtropische Anpassung zeigen,

[1] Flora of Tasmania 1 (1860).
[2] That is, Antarctic American.
[3] Plant World 18 (1915) 142.
[4] Geographie der Farne (1910) 248.

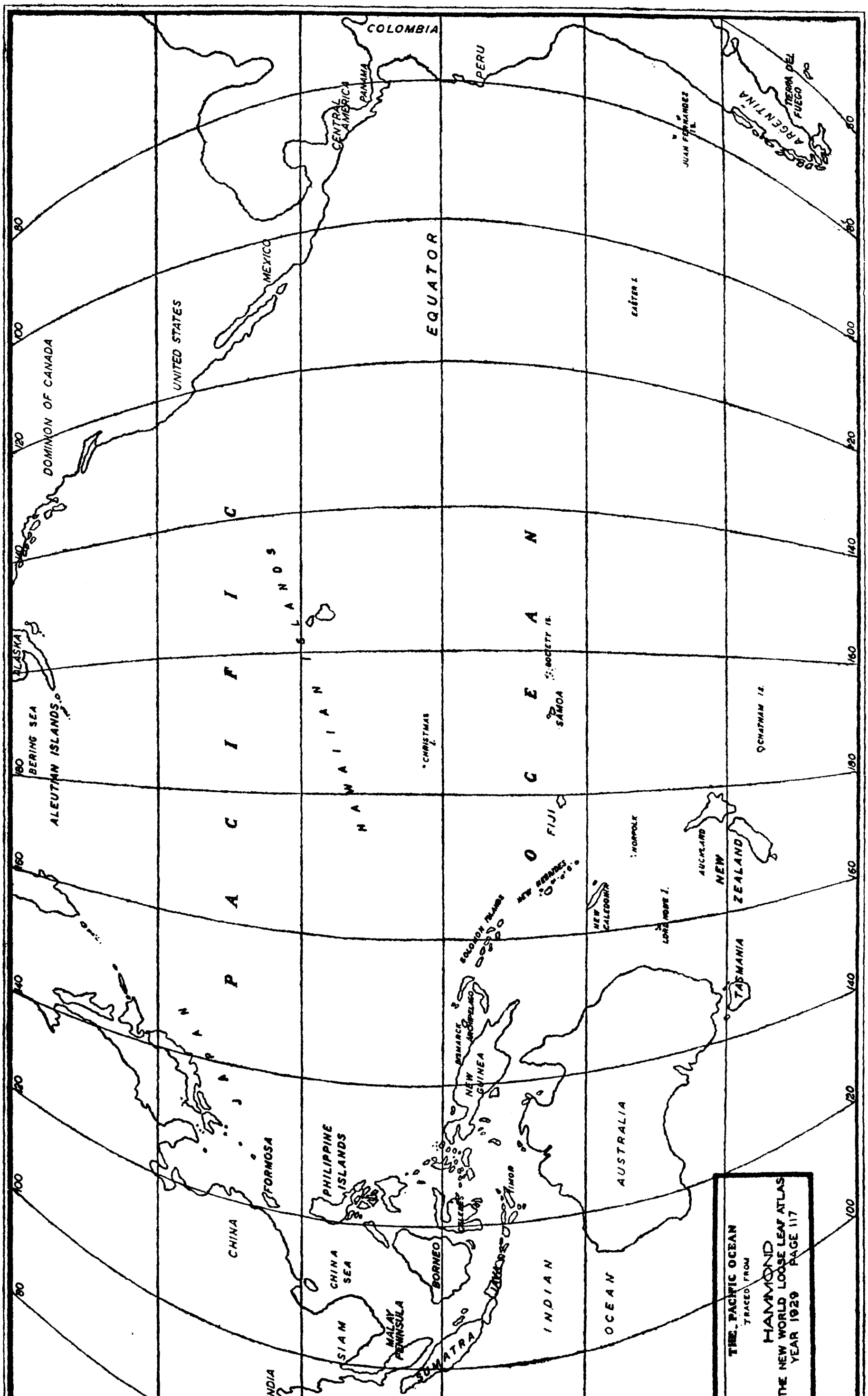


FIG. 1. The Pacific Ocean.

aber doch sich rund um den Südpol in tiefen Breiten sowohl der östlichen als westlichen Halbkugel ausdehnen. Sie sind nicht analog den arktischen Pflanzen, auch nicht den antarktischen Phanerogamen mit ihrem höchst charakteristischen Polsterhabitus, sondern nur dadurch verbunden, weil sie einen, wenn auch unterbrochenen, Kreis im tief ozeanischen Süden bilden.

Diese Arten gehören in erster Linie der neuseeländischen und überhaupt der australischen Flora an, streifen aber in die westliche Halbkugel oder doch bis S.-Afrika hinüber.

Dahin eine ganze Schar *Blechnum*: *australe, capense, tabulare, lanceolatum, attenuatum, penna marina, Polystichum capense* und *vestitum, Polypodium australe* und *Billardieri, Hymenophyllum ferrugineum, Asplenium obtusatum, Schizaea fistulosa*. . . . Auch *Hypolepis rugulosa*, ... Dahin aber muss auch gezählt werden das Genus *Dicksonia*, . .

Ebenso aber auch *Schizaea*, dieses zerfahrenste aller Genera, das aber, zwar zunächst um Neukaledonien gravitierend, doch offenbar vermöge seiner, S.-Afrika und S.-Amerika gleichmässig berührenden, Expansion entschieden auf ein Südzentrum hindeutet.

Diese Arten setzen ein solches, irgendwo im tiefen Süden gelegenes, tertiäres oder noch älteres Gebiet voraus, wo sie, genau wie so manche Blütenpflanzen gleichen Areals, den Ausgangspunkt ihrer radialen Wanderung haben. Dass dies Gebiet ein altes und warmes war bezeugt der ganze, zur Stammbildung geneigte und sehr frondose Aufbau der grossen und die Zartheit der kleineren dieser Farne . . .

Dieses nach anderen Kontinenten übergreifende Element der australischen Flora enthüllt uns die Herkunft dieser Flora überhaupt. Sie ist ein, auf den schmalen Areal Neuseelands, Tasmaniens und O.-Australiens mit ihren kleinen Satelliten, erhaltenes Relikt einer grösseren Südflora, die zur Tertiärzeit oder früher sich ausbildete, ausstrahlte und nun noch die ozeanischen Punkte bezetzt hält, und ihr klimatisch ihre Existenz sichern.

My own attention to this phenomenon came at the conclusion of a series of studies of the Hymenophyllaceæ, when the facts as to the present distribution of genera and species made me ascribe an Antarctic origin to the entire family. Now, the distribution of a dozen species might arouse our wonder, when they seemed to be isolated cases. But, once it was established that a fern family of several hundred species had this history, what had aroused wonder began to seem natural, and it appeared that it would now be wonderful if other ferns had not evolved in variety under the same favorable conditions as the Hymenophyllaceæ, and had not radiated from Antarctica at the same time as the filmy ferns. This is the more true, because dispersal over water seems likely to have been involved at all times, even if not always at all places, and the Hymenophyllaceæ are commonly believed to be disqualified for jumps to great

distances by having spores of briefer vitality than do most ferns. Moved by these considerations, I decided to subject the ferns as a whole to investigation from this point of view.

It must be observed in the beginning that the geological evidence, which fills out our picture of the past in the North, is largely wanting in the South. Not only is there no living fern in Antarctica; no fossil fern may be known there. Christ[5] reports fossils of *Cyathea, Blechnum*, and *Polypodium* from Seymour Island, from 64° south latitude; I believe they were found in Graham Land, but the difference is without interest. What geology really contributes to our understanding is summed up in italics in the Glaciology of Priestly and Wright (1922): "Glacial conditions have been the exception and not the rule in Antarctica"[6]; and "In the upper Oligocene or lower Miocene, once more a temperate to subtropical flora holds sway over some portion of the Antarctic Continent.[7] We would have had to postulate such conditions, as Christ did, from the facts of present distribution, but the argument is better when the geologist confirms it by direct evidence.

There are some general facts concerning ferns that may help to provide a foundation for the study of their history. More than nine thousand species are recognized today, in more than two hundred genera. As I divide them into families, using the latest Supplement to Christensen's Index, effective at the end of 1933, as to the numbers of genera and species, they are:

Family.	Genera.	Species.
EUSPORANGIATE FERNS		
1. Ophioglossaceæ	4	92
2. Marattiaceæ	7	217
LEPTOSPORANGIATE FERNS (FILICES)		
3. Osmundaceæ	3	20
4. Schizæaceæ	4	162
5. Gleicheniaceæ	2	120
6. Hymenophyllaceæ	4 (+2)	651 (+4)
7. Polypodiaceæ	182	8,034
8. Marsileaceæ	3	74
9. Salviniaceæ	2	16

Other especialists recognize more families. Thus, Christensen lists three others, which I include in Polypodiaceæ, and has since

[5] Op. cit., 330. [6] P. 44. [7] P. 446.

increased the number.[8] I do not know how many Bower might recognize, but certainly a much larger number. The question as to number of families is not related to the thesis of this paper; the families are listed here to give a general outline of fern classification, and to indicate the order in which they will be discussed. There are similar differences in practice as to the genera, but there is comparative uniformity as to the species. I will continue to use Christensen's figures, with few exceptions, as his Index is the nearest approximation to a common judgment of fern specialists.

However far back in geologic time the group of ferns may have originated, our living ferns are mostly a group of recent evolution; in fact, still actively evolving as a component of the world's vegetation. Although the ferns are a part of a larger group, the pteridophytes, in which seed plants are supposed to have originated, the Polypodiaceæ and Hymenophyllaceæ are families of recent and present time, just as truly as is any family of flowering plants. Their genera and species, in general, are still spreading; very few of them are commonly believed to have occupied a greater area, or been more numerous or more varied, at any previous time than they occupy and are today. Time is therefore one of the factors limiting their present range, although the necessity of suitable local conditions where the spores fall is a stronger limiting factor. Thus the total absence of Hymenophyllaceæ in our Pacific Northwest, where climatic conditions are ideal for many of them, must be explained by their not having been in northeastern Asia when the climate of Siberia and Alaska would have permitted them to spread to America. Against the scale of geologic time, this was the condition yesterday. Two species reached Saghalien and Ussuriland[9] (but the reporter mistook them for very old inhabitants), this morning, when the Behring bridge is temporarily closed.

Characteristically and in general, the ferns of today are plants of the humid Tropics, where, except in Africa, every moist mountain supports several hundred species. Four hundred thirty-seven species are known from Mount Kinabalu in Borneo, the forests of which are still far from being completely explored. With a distance from the equator, north and south, the number

[8] Verdoorn, Manual of Pteridology (1938).

[9] Kryshtofovich, A. Hymenophyllum and Trichomanes in Ussuriland. Sunyatsenia 3 (1935) 22.

of species, and their share in the vegetation, decrease, except in New Zealand and the subantarctic islands.

This great tropical fern flora might have evolved where it is, or farther north, or farther south. In the absence of evidence the simple assumption would be that it evolved where we find it, and where it is still in active evolution. We have no evidence that the Tropics as a whole were at any past time unfit for ferns; and the assumption that this has been the chief place of their evolution obviates the necessity of assuming and explaining migration in latitude. It is only when we open our eyes to anomalies in present distribution that appeal to other places of evolution becomes necessary. Some of these anomalies have been mentioned, and more will be. I will show that such cases, in varying degree of emphasis, are far commoner than has been appreciated; that over a wide range of fern evolution what have seemed to be the anomalies really illustrate the rule.

As one leaves the equator, going north, the proportion of land to water around the globe increases (text fig. 2). All ferns are land, not marine, plants. Going south, the proportion of land decreases rapidly. A reasonable expectation would be that the north temperate zone would have many more fern species than the south temperate zone, except as differences in moisture might make the North relatively unfit for ferns; and that this would be true of ferns as a whole, and of each family and genus of tropical origin. Actually the land south of the equator is on the whole drier than that of the North, which would be expected to explain the relative paucity of southern ferns.

A richer development of a genus or family to the south in spite of this better present opportunity for wealth of fern species to the north, creates a strong case for a southern, rather than a tropical, origin of the group. The diversity of genera in the family or of species in the genus being greater in the South is a strong additional reason for postulating a southern origin. For, if diversity rather than numbers be the feature of difference, the presumption is that the species and genera which impress us as peculiar, divergent, or isolated have lagged behind in northward migration.

The most obvious evidence for southern origin is presented by the cases of widely discontinuous distribution already referred to, species and genera common to southern Chile and New Zealand, with Tasmania, the Cape, Juan Fernandez, and

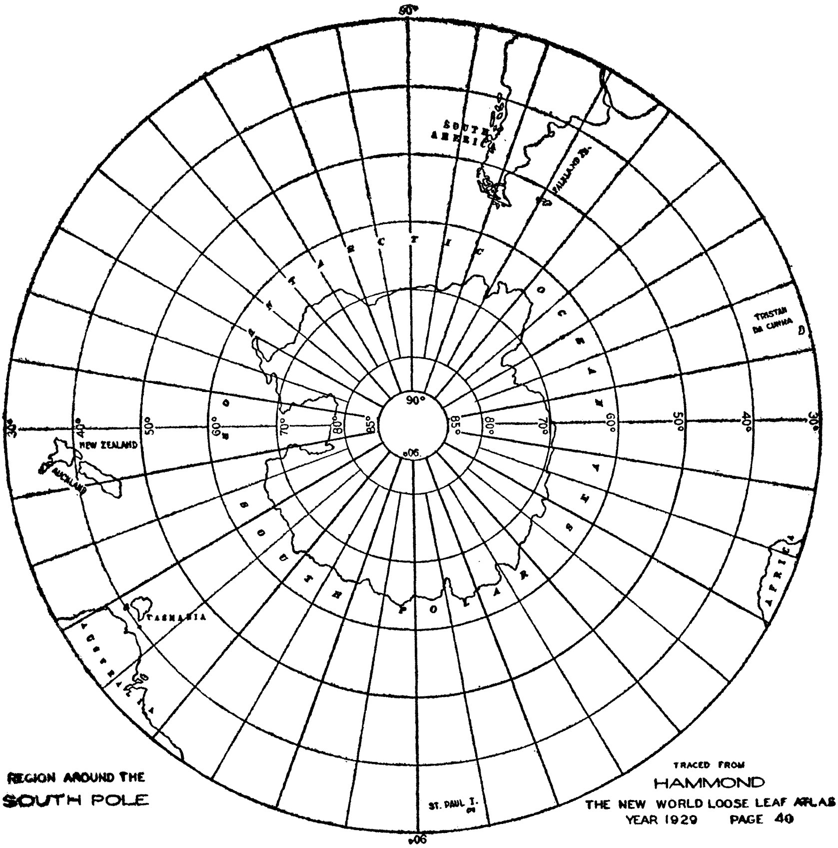


FIG. 2. The region around the South Pole.

the Falkland and other subantarctic islands as less common additional regions. Reiche [10] lists among the genera common to Chile and New Zealand: "Gleichenia, Alsophila, Dicksonia (auch J. F.), Trichomanes, Adiantum, Cheilanthes, Pellaea, Pteris, Asplenium, Polypodium, Gymnogramme, Notholaena, Schizaea (sehr ähnlich oder vielleicht identische Art), Ophioglossum, Botrychium, Lycopodium, Azolla." His list of identical species includes: "Hymenophyllum tunbridgense, ant. H. unilaterale, ant. H. rarum, Cystopteris fragilis, ant.[11] Lomaria alpina, Aspidium aculeatum, A. coriaceum."

The force of this kind of evidence is not always conceded. Thus, Diels [12] included members of groups which "at the present

[10] Grundzüge der Pflanzenverbreitung in Chile (1907) 301.

[11] "Ant." means antarctic. His *Aspidium* species are *Polystichum*.

[12] Essays in Geobotany (1935) 191: The Autochthonian flora [of Australia].

day, are distributed principally in the southern hemisphere, but it is impossible to infer that they originated in the south." Disclaiming the impossibility, I do so infer, as to the ferns; finally, as the evidence piles up, do so conclude, in many cases. The usual alternative is to picture these isolated groups as remnants of an old northern flora, exterminated in their old range by change of climate or by unendurable competition. Substitute southern for northern, and that is what they are. We know, then, that the postulated change of climate has occurred, and have no such explanation if we impute a northern origin.

The idea that plants can be driven to outposts where they are permitted to live on is a thoughtless transfer of an idea familiar and sound in the case of men. Competition can never drive a plant to a new place; it can only kill it off in its old place. Under very particular conditions, change in climate may result in migration. Thus, a glacier moving south across Canada would be associated with a change of climate in the United States, making it what the climate of Canada had been; and the change would take place slowly enough so that some Canadian plants would spread southward as the climate there became fit for them. Some plants may have been enabled to migrate from Antarctica as it chilled. Or these plants of Antarctica may have migrated previously, as plants are always doing, and then have been exterminated by cold in the land of their origin. There is no evidence whatever that any progressive change of climate, worldwide in its scope, has ever "driven" plants south in this manner, in Africa, into and across Australia, and in South America. When one explanation is integrally sound, and no other is even plausible, it is not worth while to be too timid in the acceptance of the one presented. On the same general ground, I am less cautious than were Hooker and Christ when I fix the Antarctic Continent as the source of the old far-southern flora; if it was another continent in the same place, whoever knows its name may substitute it.

In postulating the antarctic origin of any ferns, I do not have to have an opinion as to the various reasonable, unreasonable, and bizarre theories regarding land connections in geologic time. Fern spores are carried across water by the wind. Once the spores are taken up by the wind, ten miles of water is no barrier at all to their spread. One hundred miles of water may be one hundred times as great a barrier, because the spores must

hit a target, a suitable place to germinate and grow. Still, ferns spread readily across seas this wide. A thousand-mile stretch makes the obstacle again one hundred times as great as a matter of geometry; and other factors,—the limited vitality of the spores, the chance of falling or being washed out of the air, and the chance of very different climate at such a distance,—increase it materially. Ferns rarely jump a thousand miles of ocean. Still, a number of species are believed to have crossed the South Atlantic, and I believe that three genera, *Plagiogyria, Coniogramme,* and *Loxogramme,* have flown the North Pacific from Japan to Mexico, each in one single instance. It is not exactly impossible, then, that direct colonization has occurred between Chile, New Zealand, Tasmania, the Cape, and Tristan da Cunha, but the distances are great. The improbability that direct colonization has occurred in this case rests more on the small areas of take-off and target than on the distance itself. And the importance of the small areas is as much that they do not provide opportunity for the evolution of diversified floras, as that they do not provide an infinity of spores to be borne away, to come down where they may. *Plagiogyria, Coniogramme,* and *Loxogramme* had a continent on which to evolve and from which to take off, and another on which to land.

Family 1. Ophioglossaceæ.—The Ophioglossaceæ are regarded as the most primitive extant ferns, and therefore as very old. There are 2 large genera, *Ophioglossum* with 54 species, and *Botrychium* with 36 species. Both of these are cosmopolitan in distribution, and many of the species range very widely. There is some concentration of *Ophioglossum* species in the South, but no marked center of evolution and dispersal. A single species of *Botrychium, B. australe,* known only from Tasmania, Australia, New Zealand, and Argentina, may be regarded as an obvious immigrant from the south. On the whole, the distribution of both genera indicates the great age ascribed to them on other grounds. We may suppose that they were represented in Antarctica during the last period of fern luxuriance there, and that some emigrants thence still survive; but that another and probably larger element in both genera survives from a fern flora living elsewhere at the same time.

Family 2. Marattiaceæ.—Marattiaceæ, though distinctly primitive in some of its characters, has evidently undergone vigorous evolution in comparatively recent time, and is still active. It is almost wholly tropical in present distribution, confined to

moist places because of the size or fleshy nature of the leaves. Only one genus, *Marattia,* with 56 species, is common to the Oriental and American Tropics, and is confined to them except for one species in New Zealand. In such cases, of which we will find many, the view has always been that the genus reached New Zealand from the Tropics. However, the species of the old and new worlds must have had somewhere, as well as at some time, a common source. In many of the cases just referred to, we will find other reasons for regarding Antarctica as the common ancestral land. Conforming the idea to the patterns thus established, I suppose that the existing species of *Marattia* had common ancestors in Antarctica, and that the surviving New Zealand species is a remnant, marking the path of migration to New Guinea and Malaya. *Angiopteris,* with 120 species, ranges from Pitcairn Island to Réunion and Japan. Three small related genera in southeastern Asia and Malaya suggest a very old center of evolution in that region. *Danaea,* with 32 species, is confined to the American Tropics. All of these must have had a common origin; but this may well have been too long ago for anything in the present distribution to provide any clue to the region.

Family 3. Osmundaceæ.—By general agreement, these are the most primitive members of the order Filices. They must then be a very old stock, and there is abundant fossil evidence that this is so. There survive 3 genera, with some 20 recognized species, of which 13 are in *Osmunda.* They are so scattered over the world as to give no hint of any particular place of origin.

The other two genera have a different history. *Todea* was described in South Africa, and the same species is found in New Zealand and Tasmania, with a variety in Australia; that is its entire range. Only Chile is wanting to give it the whole range of the most typically limited migrant from Antarctica. Of course, it had a still older history, leading back to a common origin with *Osmunda,* in some region not to be guessed at. But, as an element of the vegetation of today, one need not hesitate to ascribe to it an antarctic origin.

Leptopteris, the third genus, has seven not too distinct species: 2 in New Zealand, 1 on Lord Howe Island, 1 in New South Wales and New Caledonia, 1 in the Solomon Islands, 1 in Polynesia and New Guinea, and 1 in New Guinea only. It is to be regarded as an antarctic genus, migrant to and through New

Zealand, undergoing specific differentiation as it went. Its nearest relative is *Todea,* and it requires little imagination to postulate their evolution as distinct genera in Antarctica.

Family 4. Schizæaceæ.—The Schizæaceæ and the Gleicheniceæ are coordinate groups, intermediate between the lower Osmundaceæ and highest, most modern ferns. The Schizæaceæ include 4 genera, with 162 species.

Schizaea includes 29 species, in three subgenera that may be regarded as closely related genera. One species I do not place. The others, listed in full to show the distribution completely, follow:

Subgenus *Euschizaea*:

S. fistulosa Labill.	New Zealand, Auckland Island, Tasmania, New Caledonia, Antarctic America, Falkland Islands.
S. bifida Willd.	New Zealand, Australia.
S. pectinata (L.) Sw.	South Africa, Madagascar, Santa Helena.
S. tenella Kaulf.	South Africa.
S. malaccana Baker.	Malaya, Burma.
S. Hallieri Richter.	Borneo.
S. robusta Baker.	Hawaii.
S. incurvata Schkuhr.	Tropical South America.
S. pusilla Pursh.	New Jersey to Newfoundland.

Subgenus *Lophidium:*

S. dichotoma (L.) Smith.	New Zealand, Polynesia to Madagascar.
S. rupestris R. Br.	Australia.
S. elegans (Vahl) Sw.	Tropical America.
S. poeppigiana Sturm.	Do.
S. fluminensis Miers.	Tropical South America.
S. pacificans Mart.	Brazil.
S. Sprucei Hooker.	Amazon.

Subgenus *Actinostachys*:

S. digitata (L.) Sw.	Polynesia to Madagascar.
S. Balansae Fourn.	New Caledonia.
S. plana Fourn.	Do.
S. tenuis Fourn.	Do.
S. intermedia Mett.	Do.
S. laevigata Mett.	Do.
S. Biroi Richter.	New Guinea.
S. spirophylla Troll.	Amboyna.
S. pennula Sw.	Tropical America.
S. penicellata H. B. W.	Tropical South America.
S. orbicularis (Baker) C. Chr.	Colombia.
S. Germani (Fée) Prantl.	West Indies, Florida.

S. fistulosa has the range most positively indicative of Antarctic origin, occurring in all major far-southern regions except South Africa, where it is represented by *S. tenella,* and with no northerly range except to New Caledonia. Still Richter [13] in a careful study of the subgenus, and recognizing this species as the approximate parent, conceived it to be New Caledonian in origin and to have migrated thence south to Tasmania, east to Chile, and west to Madagascar. Better than Richter's was Christ's earlier statement.[14]

South Africa, besides being farther from Antarctica by a critically wide margin than are Cape Horn and New Zealand, and practically without interplaced islands, is not now a favorable place for ferns. Madagascar, not so much farther north, is favorable,—it has more fern species than are now known from the whole African continent. Because it seems to be here only that fern spores carried northward in this region would now find a fair chance to effect colonization, I regard Madagascar as having been so colonized, either directly or by way of the continent, if the Cape was at the critical time a land more fit for ferns. Ferns have reached Madagascar from various directions, but Antarctica must be recognized as one likely source of them. This is important here because the other two subgenera of *Schizaea* occur in Madagascar.

Each of the other subgenera has one species ranging from Polynesia to Madagascar, and the other species either confined to New Caledonia or mostly South American.

The genus as a whole and all its subgenera are now chiefly tropical, only one species falling, in a tropical-storm path, far to the North. But the species of *Lophidium* and of *Actinostachys* in the two hemispheres (eastern and western) must have had somewhere a common origin. This may reasonably have been where the three subgenera had in turn their common source; and *Euschizaea* is patently antarctic in origin. Also, as to the other two subgenera, the old-world range is on the whole south-tropical, for the Tropic of Capricorn crosses Madagascar and just misses New Caledonia. The fern flora of New Caledonia

[13] Meded. Rijks Herb. Leiden No. 28 (1916) 4.

[14] Geographie der Farne (1910) 157: Um so klarer ist es, dass wir hier ein Genus haben, dessen Verbreitung rein historischen Ursachen zuzuschreiben ist, das einem alten Ausgangspunkt in der S.-Hemisphäre entstammt, und das heute in einem völlig fragmentären Areal vorliegt; immerhin so, dass im Norden von S.-Amerika und um Neucaledonien sich sekundäre Formenkreise gebildet haben.

has been regarded as an eastern outpost of the Malayan, but it now appears to be austral (New Zealand) in origin, and that migration has been westward rather than toward the East. The storm track leads westward on both sides of the equator.

Species of *Lygodium*:

L. articulatum A. Rich.	New Zealand.
L. circinnatum (Burm.) Sw.	Queensland to India.
L. flexuosum (L.) Sw.	Queensland to China.
L. japonicum (Thunb.) Sw.	Queensland to China, Japan.
L. hians Fourn.	New Caledonia.
L. scandens (L.) Sw.	Polynesia to Africa.
L. reticulatum Schkuhr.	Polynesia, Australia.
L. trifurcatum Baker.	Melanesia, Banka.
L. dimorphum Copel.	New Guinea.
L. Kingii Copel.	Do.
L. Moszkowskyi Brause.	Do.
L. Versteegii Christ.	New Guinea, Luzon.
L. digitatum Presl.	Philippines, Malacca.
L. semihastatum Desv.	Philippines, Mariannes.
L. basilanicum Christ.	Philippines.
L. Matthewi Copel.	Do.
L. Merrillii Copel.	Do.
L. Mearnsii Copel.	Do.
L. Teysmannii v.A.v.R.	Pulo Pisang.
L. borneense v.A.v.R.	Borneo.
L. derivatum v.A.v.R.	Lingga.
L. polystachyum Wall.	Malacca, Tenasserim.
L. salicifolium Presl.	India.
L. conforme C. Chr.	Tonkin, Hongkong.
L. subareolatum Christ.	China.
L. lanceolatum Desv.	Madagascar, Comores, East Africa.
L. Boivini Kuhn.	Madagascar, Comores, East and South Africa.
L. Kerstenii Kuhn.	Madagascar, Comores, East Africa.
L. Brycei Baker.	Rhodesia.
L. Smithianum Presl.	East Tropical Africa.
L. volubile Sw.	Tropical America.
L. polymorphum (Cav.) H. B. K.	Do.
L. mexicanum Presl.	Do.
L. heterodoxum Kunze.	Venezuela to Mexico.
L. radiatum Prantl.	Colombia to Guatemala.
L. micans Sturm.	Guiana, West Indies.
L. oligostachyum (Willd.). Desv.	West Indies.
L. cubense H. B. K.	Cuba.
L. palmatum (Bernh.) Sw.	Atlantic United States.

As the species of *Lygodium* are presented in the foregoing list, they present a clear picture of a genus which, although now almost wholly tropical, once emigrated from Antarctica by all

three of the great possible routes. Although no species survive in far-southern America, no other common source of the American and old-world species can be supported with any plausibility. The one isolated northern species may be regarded, like *Schizaea pusilla*, as a plant picked up where *Lygodium* thrives, but deposited far from its fellowship by one of the tropical hurricanes which at intervals sweep up the Atlantic coast of the United States; or it may be a sole survivor of a flora antedating the Antarctic emigration.

The species of *Lygodium* form natural groups, but there is no such uniform agreement about these as in the case of *Schizaea*. Whatever character serves as the basis of primary classification, the resulting groups are well represented in both eastern and western hemispheres. Prantl, followed by Diels in Die Natürlichen Pflanzenfamilien, recognized three major groups: (1) *Palmata*, including *L. articulatum* (New Zealand), *L. circinnatum* (Queensland to Ceylon), and *L. radiatum* (Colombia to Guatemala); (2) *Volubilia*, including *L. scandens* (with wide paleotropic range), *L. lanceolatum* (Madagascar, and other localities), and *L. volubile* (tropical America); (3) *Flexuosa*, including *L. flexuosum* (Queensland to China), *L. Karstenii* (Madagascar, and other localities), and *L. polymorphum* (throughout tropical America).

Thus the argument as to the origin of the genus applies with the same force to every major group of species. The groups existed in Antarctica before the dispersal from that region.

Fossil *Lygodium* is reported from Europe in the Cretaceous, Eocene, and Miocene. I do not guess at the subsequent history of these old European Lygodia; no plant in the genus survives in or near Europe. *Lygodium* as it exists today is more than probably of Antarctic origin.

Mohria, whether one polymorphous species or several similar species, is found in Africa from the Cape to the equator, in Madagascar and in the Mascarenes. It might be autochthonous in that region; but it is simpler to regard it as Antarctic; since it must have had a common source with the other genera of its family, we ascribe their evolution to Antarctica, and can regard Antarctica as the normal source of a South African plant.

In *Anemia* 91 species are recognized, of which 86 are American, reaching beyond the Tropics, with 1 species each in Florida and Texas, and several in southern Brazil. The others are one

in South America and Madagascar, 3 endemic in Madagascar, and one in Abyssinia and India. This distribution has served as a remarkable illustration of the connection of the floras of South America and eastern Africa and Madagascar. It would be as easy to believe that the connection was by way of Antarctica, as that it was direct; and after it becomes probable that the other genera of the family were once Antarctic, the necessity of a common source of all the genera makes the distribution of *Anemia* serve as additional evidence. The genus has undergone very active recent evolution in South America.

Considering that the distribution of all the genera, and all the species of the family with one possible exception, can be explained by imputing an Antarctic origin to the family, and that the distribution of *Anemia* and *Lygodium* and of their subgenera or groups of species fairly demonstrates this origin, we may, with more than reasonable confidence, regard the extant Schizæaceæ collectively as migrants from Antarctica.

Family 5. Gleicheniaceæ.—Gleicheniaceæ consists of 2 genera (or better, 5), and includes 120 species, of which the Index places 1 in *Stromatopteris*, and 119 in *Gleichenia*. The latter fall into 4 subgenera, to which I prefer to give generic rank, as Christensen does in the latest expression of his views. The argument is the same, whatever the rank given to the groups.

Gleichenia in the stricter sense (9 species), *Platyzoma* (1 species), and *Stromatopteris* constitute a closely related group, small enough so that the species may be listed, to show their positively southern character:

Gleichenia polypodioides Sw.	South Africa, Madagascar, Amsterdam Island.
G. circinnata Sw.	New Zealand, Tasmania, Australia, New Caledonia, Borneo, Malacca.
G. dicarpa R. Br.	Tasmania, Australia, New Caledonia.
G. alpina R. Br.	New Zealand, Tasmania, Samoa.
G. rupestris R. Br.	Australia, New Caledonia.
G. vulcanica Blume.	Malaya.
G. peltophora Copel.	Mindanao.
G. madagascariensis C. Chr.	Madagascar.
G. Boryi Kunze.	Réunion.
Platyzoma microphyllum R. Br.	Australia.
Stromatopteris moniliformis Mett.	New Caledonia.

The Antarctic origin of this group of genera is too obviously probable to require any argument.

The other 2 genera are *Dicranopteris* with a few species, and *Sticherus* with nearly one hundred. *Dicranopteris* is typified by *D. linearis* (Burm.) Und., common throughout the Oriental Tropics and in New Zealand. Its American vicar is *D. pectinata* (Willd.) Und. Once the idea is familiar, it is easy to recognize a genus in the Tropics of both hemispheres, and surviving as far south as New Zealand, as being Antarctic in origin.

The type of *Sticherus* is the Malayan *S. laevigata* (Willd.) Presl. There are many species in all tropical lands, and at least two range northward to Japan. The southern character of the genus is strongly emphasized by the presence of 5 species in southern Chile, 1 of them in the Falkland Islands and 1 in Juan Fernandez; 3 in New Zealand, 1 of them and 1 other in Tasmania; 1 in South Africa, and 1 in Madagascar, the Seychelles, and the Mascarenes. The northward distribution is unbroken along every path of migration into the Tropics. The Chilean, New Zealand, and South African stragglers along the way point out more than sufficiently the common source, still farther south, of the many species of the Tropics, Oriental and American.

Summing up: All genera of Gleicheniaceæ having more than one species give individual evidence of Antarctic origin, and the monotypic genera are found where an Antarctic origin is easy to assume. As a component of the living flora, this family is entirely Antarctic at some stage of its history.

Family 6. Hymenophyllaceæ.—I have presented the evidence concerning the Hymenophyllaceæ elsewhere [15] and it will suffice to summarize it here. I recognize 32 genera, in contrast with the 4 (and 651 species) in the Index. Of these, *Hymenophyllum, Meringium, Mecodium, Sphaerocionium, Vandenboschia, Selenodesmium,* and *Didymoglossum* occur in both hemispheres (eastern and western), and all have far-southern extant species. There survive also, in the far South only, *Cardiomanes, Polyphlebium,* and *Apteropteris* in New Zealand, and *Serpyllopsis, Hymenoglossum,* and *Leptocionium* in subantarctic America. There are other genera in only one hemisphere, with their appropriate southern representatives. And the genera confined to the Tropics are regarded as derived from specified genera of evident southern origin.

[15] Philip. Journ. Sci. 67 (1938) 1.

These filmy ferns are particularly dependent upon humidity. If humid regions only be considered, the number of their species in proportion to all fern species increases steadily with south latitude, from less than one in one hundred north of the Tropic of Cancer to one in twelve in the Tropics, one in five in New Zealand, and one in three in Stewart Island. In Juan Fernandez they are not quite one in three, but may exceed half in the Falkland Islands. This seems to suggest that in old Antarctica the Hymenophyllaceæ were fairly comparable in numbers with the Polypodiaceæ. The latter also are largely of the same origin, but the Hymenophyllaceæ have fallen behind, for two reasons: They are relatively incapable migrants; and have been relatively inactive in recent evolution in the Tropics.

No other plant family of its size and diversity is quite so conspicuously Antarctic in origin as this one.

Family 7. Polypodiaceæ.—The families so far discussed have been evident phyletic entities, "natural families." The components of each could therefore be assumed to have a common ancestry and a specific common place of origin. The Polypodiaceæ, as usually limited, excluding *Dicksonia, Cyathea,* and *Matonia* (if these are excluded, so should be *Plagiogyria*), are not a natural family, though they are an easily defined one. Quite certainly, their genera represent three freely branched phyletic lines of distinct outside origin, related respectively to *Dicksonia, Cyathea,* and *Matonia,* usually treated as representing two or three distinct families. In an attempt to make the family natural, that is, to make it have a single outside ancestral source, I made it include the genera mentioned; and may not even then have succeeded. Each of these genera has a large number of related genera, "cousins, brothers, descendants, and nephews." Not all Polypodiaceæ fall evidently into any of these three groups, but most of them do. Not knowing a common ancestor of the three, I cannot try to assign it a place in geography; and at any rate, such a common ancestor would have to be sought farther back in time than I suppose the major evolution of ferns in Antarctica, and the migration thence to have occurred. The three will therefore have to be considered in succession.

The Polypodiaceæ, whatever the scope of the family, are regarded as the "highest," most modern ferns, those of most recent evolution. As to many genera confined to their several limited regions, this is altogether true; they evolved where they are, so recently that the time they have had limits their range. As to the family as a whole, it has been assumed to have passed

its evolution through stages to which those of the Schizæaceæ and Gleicheniaceæ correspond. If this meant that they were descended from these families, we could conclude directly that they must have a common source in geography, that the Polypodiaceæ collectively are also of probable Antarctic origin. However, the sounder opinion is that a common ancestor of the families lived so long ago that present distribution can give us no clue to the region it inhabited, if, indeed, there was any one definable region. This leaves us to test *Dicksonia* and other primitive Polypodiaceæ as we did *Schizaea*, to see if the present distribution of the species indicates a definite common source. By this time we are justified, however, in approaching the problem with some prejudice; because we know now that evolution in Antarctica and migration thence are responsible for the distribution of many ferns, and that the conditions responsible in their cases may well have operated similarly with those still to be considered.

In *Dicksonia* the distribution of the species is:

New Zealand, 3; Tasmania and Australia, 1; New South Wales and Queensland, 1; New Caledonia, 3; Fiji and Samoa, 1; New Guinea, 4; Malaya, 1; in all, 14 radiant along the New Zealand–Tasmania path.

Juan Fernandez, 1; Peru, 2; Equador and Brazil, 1; Colombia and Central America, 3; Mexico, 1; in all, 8 along the Andean path.

Saint Helena, 1.

This distribution can by this time speak for itself.

Genera related to *Dicksonia* and about equally advanced in a morphological sense are *Thyrsopteris* and *Cibotium*. *Thyrsopteris* has one species, endemic, on Juan Fernandez. As Juan Fernandez can hardly have evolved so peculiar a fern, its most reasonable origin, as a Juan Fernandez fern, is Antarctica, whether directly or through southern Chile. European fossils have been referred to this genus, but Juan Fernandez was not colonized from Europe,—before Robinson Crusoe.

Cibotium has 3 species in Malaya and China, 4 in Hawaii, and 5 in Mexico and Central America. One will not hastily use a genus without a species south of the Tropics as evidence of Antarctic origin. Still, the strangely discontinuous distribution must have an explanation, and the fern flora of Hawaii is almost wholly of southern origin. It may be that the story of *Cibotium* began too long ago for its scene to be guessed at; but if we do try to determine its history from its distribution,

the most reasonable theory is that it reached its present isolated stations from the South.

Culcita seems to stand between *Dicksonia* and *Dennstaedtia.* It has 1 species in Australia, 2 in western Polynesia, 3 in Malaya including Luzon, 1 in Formosa, 1 in tropical America, and 1 in the Atlantic Islands. It has lost its far-southern connections, but its discontinuous distribution, taken with its affinity to *Dicksonia,* indicate such an origin.

The preceding 4 genera are sometimes treated as belonging in a separate family, Dicksoniaceæ. However, *Dennstaedtia,* clearly related to *Culcita,* is always included in Polypodiaceæ. It is a genus of 70 species; and *Microlepia,* which blends with it, has 45. Nearly all are tropical. One species is in the United States, and several reach Japan, but these are not so related as to suggest an old northern connection. In the other direction, *D. glauca* (Cav.) C. Chr. ranges from lower Chile to Bolivia; *D. davallioides* (R. Br.) Moore is in Tasmania and Australia; *M. Pinckneyi* (Col.) C. Chr. is in New Zealand; and *M. madagascariensis* is where its name indicates. *M. Speluncae* (L.) Moore, in both New Zealand and Madagascar, has spread over all tropical lands. *Dennstaedtia* is reported by Berry [16] in the upper cretaceous of Patagonia. Aside from the fact that their relatives suggest a southern origin, this is the simplest explanation of the range of these 2 genera. Their recent evolution in the Tropics has been active.

Hypolepis and *Paesia* are so near to one group of species in *Dennstaedtia* that my Bagobo botanist friend Angat gave one name to the three, though he had another name for another *Dennstaedtia,* and accurately distinguished by name an amazing number of ferns. *Hypolepis* has 45 to 50 species, half of them in the American Tropics, without surviving Chilean representatives. In the old world the paths from the South are still well marked. South Africa has 2 species, one of them reaching the Mascarenes and Fernando Po; another is in Abyssinia; and *H. punctata* is found on islands on both sides of Africa. New Zealand has 6 species, of which *H. dicksonioides* (Bory) Hooker reaches to Australia and Polynesia; *H. rugosula* (Lab.) J. Sm., farther into the Tropics; *H. tenuifolia* (Forster) Bernh., to China; and *H. punctata* (Thunb.) Mett., to Japan. The path of migration remains peopled by more local species,—*H. elegans* Carr. on Lord Howe, Aneityum, and Fiji, others in New Cale-

[16] Science 86 (1937) 221.

donia, New Guinea, Malaya, the Philippines, and Formosa. One species is endemic in Hawaii. *Hypolepis* conforms to the picture of an old Antarctic genus now at home chiefly in the Tropics, but with two of the paths from the South still occupied.

Paesia has 1 New Zealand species, said to be in New Guinea also, 1 in New Caledonia, 1 endemic in New Guinea, 2 in the Philippines, 1 in Sumatra, 2 in Tahiti, and 4 in America, from Peru to Jamaica. On its small scale, the story is the same as that of *Hypolepis*.

Nearly enough related to *Paesia* to have sometimes been united with it is *Pteridium*, the bracken, one of the most cosmopolitan ferns. It occupies paths of migration from the South, and must have lived in Antarctica, but that may or may not have much to do with its present distribution. Another relative, *Histiopteris*, has a few local derived species and one, *H. incisa* (Thunb.) Ag., is pantropic in present distribution, but also in so many far-southern lands that its Antarctic origin is hardly questionable. Another relative is *Lonchitis*, including *Anisosorus* of the Index. It has 11 species: 5 in the American Tropics and 6 in Africa, especially developed in the South and in Madagascar. It may evidently be of Antarctic origin, and is best so regarded because it must share its origin with its relatives.

We come now to *Pteris*, a genus of 269 recognized species. As is true of all really large genera, its great wealth of species is in the Tropics. The species with reticulate venation constitute a subgenus, *Litobrochia*, nearly related to *Lonchitis*, which I regard as the more primitive element of the genus. *Litobrochia* has two New Zealand species, one endemic, the other, *P. comans* Forster, being found also in Tasmania and Juan Fernandez, as well as in Polynesia. It thus survives to mark the paths of migration into the Tropics of both hemispheres, where there are many other species of more restricted range, and so presumably younger.

Eu-Pteris, with free veins, contains several groups, perhaps independently related to *Litobrochia*. *P. cretica* L. is in New Zealand and South Africa, ranging northward to Japan, the Mediterranean, and into the United States. *P. vittata* has the same old-world range. *P. tremula* R. Br. is in New Zealand, Tasmania, and doubtfully in South Africa. Each of these three represents a natural group of species. *P. chilensis* is in Chile and Juan Fernandez; there are 2 other Chilean species.

P. paleacea is endemic in Santa Helena. A genus with about 260 species in the Tropics, and 5 confined to the far South, might be presumed to be tropical in origin. When, however, we consider the probability that the forbears of *Pteris* were Antarctic, and the fact that most wide-ranging, and therefore probably oldest and most primitive species of the several groups still exist in the South, we recognize the southern survivors as laggards along the path of migration, and conclude, too, that the differentiation of the groups preceded the northward migration. The present multitude of tropical species merely demonstrates the use of the recent and present opportunity for evolution under perfect and diversified climatic conditions, with ample room.

Adiantum, with 226 species, is the other large genus of this alliance. It is more isolated (without near relatives), and therefore presumably older. It has a disproportionate number of southern species, 12 in Madagascar, 7 in New Zealand. *A. scabrum* Kaulf. and *A. sulphureum* Kaulf. represent it in southern Chile, and *A. tenerum* Sw. in Juan Fernandez. *A. aethiopicum* L. is in South Africa and New Zealand, but does not range far north. *A. hispidulum* Sw. is in the same southern lands, but is distributed as continuously as land and climate permit from both of them to India. There are also a few distinctly northern species, notably *A. pedatum* L. The reasonable conclusion is that Antarctica has played a major part in the history of today's *Adiantum,* but that the genus may include elements surviving from other floras and from an age prior to the great dispersal from the South.

The fondness of gardeners for *Adiantum* is based jointly on its beauty and on the ease of reproducing it by spores. Some thirty years ago, Dr. W. R. Shaw, in work never published, undertook to grow in the laboratory a large number of Philippine ferns. The spores of every common fern, and of almost no rare fern, germinated for him. This should go far to explain why some ferns are common and others rare, a phenomenon too completely ascribed to other factors,—climate, exposure, soil, age. Every tested *Adiantum* germinated, and its spores are evidently exceptional in vigor and viability. The spores of *A. philippense* L., common about Manila, were probably brought inadvertently to Acapulco by the galleons. It is now well established in southern Mexico, and has reached Central America. This matter of the viability and vigor of the spores, as far as

we are informed about it, should be taken into account in any study of the significance of distribution. The time which permits an *Adiantum* to acquire a wide range might leave a *Cyathea,* difficult to cultivate by spores, still almost local.

Going back to *Dennstaedtia,* another revolutionary line leads to *Lindsaya,* a genus of 159 species, with the same distribution picture as *Dennstaedtia.* It has 5 New Zealand species, and 7 in Madagascar. Its related genera are similarly distributed. Several other groups of genera are traceable back to the *Dicksonia* group, and present essentially the same present map as the coördinate groups already discussed. The itemization of the evidence, and repeated drawing of the same conclusions, become too monotonous; and the validity of the argument ceases to gain strength by repetition, once it is well established.

There is, however, one group of very many genera which presents distinct problems, that of *Cheilanthes* and its relatives, to which the genera often treated as a tribe typified by *Gymnogramme* are related by so many ties that all, together, must constitute one natural alliance. Christ aptly characterized these as the xerophilous ferns, the ferns of dry lands. There is evidence enough for the southern origin of the group as a whole. But this evidence would become perfect, as in the case of the Hymenophyllaceæ, only if the several genera were shown to be Antarctic in origin, thus fixing Antarctica as the place of their evolution. I cannot do this for the group in question, because there is no sound agreement as to what the genera are. The large cheilanthoid genera of the Index are not such in any proper sense. *Cheilanthes* and *Pellaea* are unnatural aggregates of genera, as is probably true of *Gymnogramme,* and certainly of *Notholaena.*

Such a study as this may be most helpful in determining the real genera. For, the morphologist can never draw a conclusion as to the relationships of a plant without at the same time postulating its history. His ultimate subject is phylogeny; and where this field is still dark, a little light from the side of history may make its exploration easy. The presumption that the differentiation of the genera occurred in the far South, and that they migrated northward along a few known paths, may provide this light. A decade ago [17] I outlined the phylogeny of the typically oriental genera, but abstained from speculation

[17] The Oriental Genera of Polypodiaceæ. Univ. Calif. Publ. Bot. (1928).

as to the relatives of *Cheilanthes,* believing that their evolution had taken place in America. Subsequent study of American ferns has cleared up only minor details. Now I conclude that this differentiation of the principal genera did not take place in America, either. Unfortunately we have not the ferns of oligocene Antarctica, but a study of the survivors along the paths of migration is still inviting.

To summarize as to the dicksoniid ferns: Their general evolution occurred in Antarctica. The principal genera were differentiated there, and their present representatives are migrants thence, or the descendants of migrants. This accounts for roughly one-fifth of all Polypodiaceæ.

In *Cyathea* must be included very nearly, but not quite, all of the species of *Alsophila* and *Hemitelia* rather than be left in those genera, making *Cyathea* a genus of about 750 species. *Lophosoria,* one variable species, and *Metaxya,* one species, are clearly distinct and primitive. The tree ferns as a whole await the study which may show how they can be broken up into natural genera of convenient size. This leaves us where we were with the Hymenophyllaceæ divided into 2 genera only and their Antarctic origin not suspected. There is no such proportion of far-southern to tropical species in *Cyathea* as there was in *Hymenophyllum,* because the current evolution of the tree ferns is exceedingly active, a very large part of the recognized species being strictly local. Still, the southern character of the group is clear, in broad lines if not in detail. A few species pass the Tropic of Cancer in Formosa, and one reaches Japan proper. As far as numbers go, just within the Tropics, Madagascar's 29 species are offset in Luzon, but there are two significant differences: Luzon is open to free colonization from the South, while Madagascar is comparatively cut off from the North; and one of the groups susceptible of generic status is confined to Madagascar. More significant in the latter way is the abundance in southern Chile and Juan Fernandez of *Lophosoria* (which ranges northward to Mexico), a primitive member of the group. New Zealand has seven species, and at least four more are extratropical in the same region.

No ferns are suspected of descent from *Cyathea.* Nevertheless, about one-third of the species usually included in Polypodiaceæ seem to have a common ancestor with it, to be much nearer to it than any other comparatively primitive ferns, and therefore likely to have the same origin in ancient geography.

Four important genera are nearly related in their more primitive representatives: *Dryopteris, Polystichum, Athyrium,* and *Cystopteris*. *Cystopteris fragilis* (L.) Benth. is conspicuously common in the far South and about equally so in the far North. It is too perfectly cosmopolitan for its distribution to present evidence for anything except that it spreads with facility and is not very new.

Dryopteris, 1,213 species in the Index, is an assemblage of genera that must be segregated in their entirety before they are ready for use in a study based on distribution. This genus also is found in the Upper Cretaceous of Patagonia. I have little doubt that the group as a whole is of southern origin; but, as in the case of *Cheilanthes,* will suggest this as a point of view in the study of the group, rather than attempt a detailed argument while I am not sure of the genera to which the southern species should be assigned.

Polystichum, 225 species, is a smaller collection of potential genera, in part so near to a part of *Dryopteris* that species are constantly shifted back and forth, not as a matter of definition, but because their nearer affinity is in doubt. The species are most numerous in and near China, evidently the center of greatest recent evolutionary activity. This recent activity, though, is in the least primitive section of the genus, that with simply pinnate fronds, represented in the South only in South Africa. The most compound element in the genus, nearer to *Dryopteris,* is represented by *P. adiantiforme* (Forster) J. Sm., in New Zealand, the Cape, Chile, and Juan Fernandez. *P. aristatum* (Forster) Presl. is in Natal, New Zealand, Rapa, and Pitcairn in the remote South Pacific, and ranges northward to Japan. The cosmopolitan group of *P. aculeatum,*—that species itself in South Africa,—is the best represented in the far South. *P. mohrioides* (Bory) Presl is a typical survivor of the Antarctic flora, in Antarctic America and all neighboring islands, Tristan da Cunha in the middle South Atlantic, and Amsterdam and Saint Paul islands in the southern Indian Ocean, with a northward range only to Peru. *P. vestitum* (Forster) Presl is in Tasmania, New Zealand, and Antarctic America. In all, Chile has 9 species, besides one in Juan Fernandez; New Zealand, 7; South Africa, 6; and the tiny island of Rapa, well out of the Tropics and two thousand miles east of New Zealand, has 3. The case for an Antarctic origin of *Polystichum* is so clear that the evidence has long been familiar, even to those hes-

itant to draw the obvious conclusion. The origin of *Polystichum* being established, the necessity of a common geographic origin for *Polystichum* and *Dryopteris* helps to fix that of the latter genus.

A considerable number of genera are dryopterid in ancestry and must therefore have a common old geographic center. Some of these indicate it by their distribution. But the argument is not impaired by others which do not, being evidently younger, evolved since the dispersal, in the regions to which they are still confined. The listing of the genera, with the respective arguments, would be superfluous.

Athyrium, if *Diplazium* be included, is a genus of 568 species. It is so in need of revision, and of the recognition or discovery of the component natural groups, that I content myself here with indicating its probable or assumed affinity to *Dryopteris* and *Blechnum*, and the consequent necessity of a common geographic origin.

Blechnum, 180 species, is one of the most obviously austral genera. It is the only large genus which, in spite of the disparity of the land areas, still has many more species (131 to 78) south of the equator than north of it. Significant species are *B. attenuatum* (Sw.) Mett., in South Africa and New South Wales; *B. tabulare* (Thunb.) Kuhn, in South Africa and South America, even to Desolation Island; *B. australe* L., in South Africa and several far-southern islands; *B. lanceolatum* (R. Br.) Sturm, in Chile, New Zealand, and Tasmania; and *B. Penna-marina* (Thunb.) Kuhn, with circumpolar distribution missing few possible spots. In all, South Africa has 8 species, Antarctic America 15 besides 3 endemics in Juan Fernandez, and New Zealand 15. Farther along a main route of migration, New Caledonia is remarkably rich in this genus.

Remarkable in a group so predominantly southern is the northern circumpolar range of *Blechnum spicant* L. *Blechnum* is not a young genus, and may be a remnant of a flora as old as the Cretaceous,—that is, "pre-Antarctic." Or, even this species may possibly be of southern origin, along with its congeners. The time between the great migration from Antarctica, Miocene at the most recent, and the refrigeration of the North which made the present distribution of *B. spicant* somewhat discontinuous, could easily have permitted a fern particularly able to migrate to reach the neighborhood of the other pole and spread over that region, while the climate there

was the same it had evolved in adaptation to in the South. *B. spicant* and *B. Penna-marina* are near relatives.

The huge genus *Asplenium*, 664 species after the removal of *Loxoscaphe*, is a collection of groups of species, very badly in need of revision. Some of these groups are manifestly of southern origin; others not so evidently so, but presenting no evidence on the other side. It has always been assumed to be nearly related to *Athyrium*. If this be so, it is a younger genus; and unless both date from some such period as the Cretaceous, it must be wholly of southern origin if *Athyrium* is so. I think it probable that *Asplenium* is wholly southern, but would not like to rest the case on its affinity to *Athyrium*.

What is true of *Asplenium* must be true, even if indirectly, of the genera derived from it. As to some of them, *Stenochlaena* and its apparent relatives, and *Diplora*, this looks probable from their own distribution. Others, such as *Phyllitis*, are newer, evolved since the dispersal, even if old enough to have their present range influenced by the northern glaciation.

To sum up on the *Cyathea-Dryopteris-Athyrium* series of genera: some of them are positively Antarctic in origin; others are probably so. Chiefly because the really natural genera combined at present in *Dryopteris*, *Asplenium*, and others are too insufficiently understood to serve the purpose, the evidence is hardly as complete and perfect as it is for the dicksoniid series; but it is good enough to make highly probable the southern origin of the group as a whole. More than one-third of all fern species are in this series.

Polypodium and its relatives constitute the third great group of genera in this family. They are believed to be descended from ancient ferns now most nearly represented by *Dipteris*, or, still more primitive, by *Matonia*, and may be called the *Matonia-Dipteris-Polypodium* series. Fossils of ferns believed to be near the living *Matonia* and *Dipteris* are known in the North, and it is not known that either of these was ever in the South. *Polypodium* itself, typified by *P. vulgare* L., and including many species which have been called *Goniophlebium*, must, by the criteria we have been using, be regarded as a northern genus. However, there is no presumption that the taxonomic type represents the genus in any other respect; and the great genus *Polypodium* of the Index, with 1,127 species, includes elements which seem to be immigrant to the Tropics from the South.

Grammitis, a remarkably uniform genus of about 125 species, is one of these. The species known only from south of the equator, about 65, outnumber those known only from north of it, about 35, and ranging across it, about 25, together. It has one circumpolar species, *G. Billardieri* Willd., in New Zealand, South Africa, Antarctic America, and several Antarctic islands. The genus migrated northward by the three great routes, some 15 species being American, about 90 Oriental, and nearly 20 African (including islands); and no species except *G. Billiardieri* is common to two of these. The case for its Antarctic origin is plain enough.

Loxogramme, 36 species, is very nearly related to *Grammitis.* It inhabits less humid woods, and therefore its spores pass more readily into free air; therefore, its species are in general less local,—the difference in this respect is very marked. Migrating easily, *Loxogramme* has passed *Grammitis,* and becomes a genus of the northern Tropics, with a number of species beyond the Tropic of Cancer, even in Japan. A single species, *L. Dictyopteris* (Mett.) Copel., survives in New Zealand. Four species are African, perhaps immigrants via the Cape, perhaps from Malaya. A single American species is Mexican, and I regard it as of recent Japanese origin.

The case of *Loxogramme* illustrates the control of judgment by the point of view. If the assumption were that ferns are a northern group, *Loxogramme,* with 16 species known only north of the equator and 6 only south of it; with 5 species known in and north of Formosa, and 1 in New Zealand, and with this one interpreted then as migrant from the Tropics with most other New Zealand ferns;—*Loxogramme* would conform perfectly to the assumption. On the other hand, recognizing *Loxogramme* as a near relative of *Grammitis,* and *Grammitis* as a southern genus; interpreting the difference in distribution to the north as a natural result of a difference in facility of migration, which I know on other grounds to exist; knowing that the Japanese region has been populated on a great scale by ferns from the South; believing that no fern has reached New Zealand from the Tropics in a million years, and that this can be so only because migration to New Zealand from the North is effectively impossible, I fit *Loxogramme* into my picture of a fern world of far-southern origin.

Several smaller genera of this series are clearly Antarctic in origin; such are *Synammia* and *Dictymia.* Others are of more recent evolution, with Antarctic forbears; this is the ap-

parent case with *Scleroglossum* and *Calymmodon*. Of larger genera, *Cyclophorus* with 100 species, and *Ctenopteris* with 200, are more than probably austral in ancestry. The largest genus of this series, after *Polypodium* is broken up, is *Elaphoglossum*. Several items of evidence indicate that it too has come to the Tropics from the far South. A natural grouping of its more than 350 species is necessary before this becomes a conclusion instead of a probability.

To sum up as to the *Matonia-Dipteris-Polypodium* series: There is good evidence for the Antarctic origin of about half of the species. As to the others, or most of them, the evidence of present distribution is compatible with this idea, but has less affirmative value. And even as to *Polypodium*, distinctively northern now, I have already pointed out that time, which has not yet permitted ferns of little expansive power, like the Hymenophyllaceæ, *Cyathea*, *Dicksonia*, and *Grammitis* to reach northern lands, was quite sufficient to permit more capable migrants to become established there long ago. However, *Polypodium* is probably no such capable migrant as *Adiantum*, *Dryopteris*, and *Athyrium*.

Family 8. Marsileaceæ.—The family Marsileaceæ includes 3 genera; *Marsilea* with 67 species, and *Pilularia* with 6, both of world-wide distribution, and the third known only in southern Brazil. These are aquatic ferns, with sporocarps too large to be wind-borne, and spores of the briefest vitality once they are exposed. Migration to any distance is probably dependent upon birds. The southern origin of *Marsilea* is indicated by the fact that more than half of all known species are African, 24, and Australian, 16. Of the 6 species of *Pilularia*, one ranges from Chile to California; one is endemic in New Zealand; one in Tasmania and Australia. Comment is unnecessary. Bower relates this family to the Schizæaceæ, and the evidence of distribution points clearly to the same old common home.

Family 9. Salviniaceæ.—The family Salviniaceæ includes 2 genera: *Azolla*, 6 species; *Salvinia*, 10. These are floating aquatics, with smaller sporocarps, more readily carried by birds: the species, accordingly, are of wider range than those of the Marsileaceæ. *Azolla filiculoides* Lam. is in Chile, Argentina, Brazil, and California. *A. pinnata* R. Br. is in Australia, ranging to Japan and Africa. *A. rubra* R. Br. is confined to New Zealand and Australia. These being half of the species in the genus, it may be concluded that the genus was

Antarctic, and emigrated by at least two routes. As to *Salvinia,* the species are largely tropical, but so scattered that no conclusion may be drawn from present distribution and ranges.

This ends the canvass of the families, and brings us to the conclusion that more than half of the living fern species are descendants of migrants from Antarctica. The geologist tells us that such migration from Antarctica itself ceased by the Miocene; it might have occurred indefinitely earlier, but there is nothing in present distribution which demands an earlier date. While the migration from Antarctica ceased at such a time, the plants then established outside Antarctica continued to multiply, to evolve new species and new genera, and to spread, northward, and fanwise, as wind carried the spores and there was fit land to receive them. And these processes of migration and evolution still go on. The evidence adduced applies to more than half of the living ferns. No comparable evidence indicates any other particular origin for one-tenth of the species. To the more-than-half, of fairly demonstrable southern ancestry, analogy and apparent affinity will justify the addition of at least another quarter.

Antarctica has played, in its time, a dominant part in the evolution of our fern world. This is our thesis. But there are corollaries, and incidental conclusions, and new questions inviting further study. The thesis is a new light on pteridology, in a measure a new light on the history of plants, and a new light brings out things that were dark. The number of New Caledonian ferns has long been regarded as remarkable. But when it is realized that New Caledonia is the first island of any size with a moist, warm climate along a main line of migration into the Tropics, and thus has an old flora as tropical fern floras go, it is plainly only natural that it has become rich in species. Madagascar, similarly placed on another path, is likewise and for the same reason rich in ferns.

New Guinea has the world's richest fern flora; Christensen [18] believes that it will prove to have 2,000 species. Borneo has been famous for its wealth of ferns, but no estimate has placed its number above 1,000. If Malaya were the center of evolution and distribution it has been supposed to be, Borneo should be the richest fern land in the world. But when we realize that

[18] Brittonia 2.

New Guinea was the first land with ideal and diversified climate and large enough to favor the free evolution of species, along the open path of migration from New Zealand and Tasmania, and that therefore it has the oldest great fern flora in the Orient, its wealth of species is only what would be expected. The old concept of a Malayan flora spreading across New Guinea to Polynesia, which I have accepted and presented as one of the data of fern geography, was essentially wrong. Between Papua and Malaya, fern migration has been from the richer to the poorer flora, with the wind, chiefly westward.

What about migration within Polynesia? Has it been, as assumed, eastward,—say from the New Hebrides and the Solomons to Fiji, Samoa, Tahiti, and even to Pitcairn and Henderson? Or did Rapa once receive ferns from the South, and pass them along to the North and West?

We have always been rather surprised by the affinity of Mindanao and New Guinea ferns, but will be so no longer. As climates are today, Celebes being in general drier than New Guinea, Mindanao, and Borneo, Mindanao was the most ready recipient of spores from New Guinea. We have always seen a dominant Malayan element in the Philippine flora. How real is it? Did ferns really come from Borneo to Mindanao, as much as they went from Mindanao to Borneo?

A great fern center, of radiation as well as of endemism, has been postulated in the Yunnan-Assam region. Is it as important as it has seemed to be? Is it still a sound presumption that a fern found here and in Formosa and Luzon originated on the continent? This should be tested case by case before the presumption is maintained. It may be correct as to *Plagiogyria*, and not as to *Cheilanthes*. The foregoing are but samples of the questions that arise or are revived.

The conditions of fern dissemination have been assumed more than investigated. They have to be considered in such a study as this, and surely ought to be studied themselves. Limited vitality of the spores has been assumed to limit the possible distance of flight over the sea, even to the point of postulating old land connections to explain the presence of Hymenophyllaceæ on remote islands. I rate this as in general a minor factor. But I do not understand the northern occurrence of one and only one *Schizaea; Schizaea* inhabits exposed places, whence the spores should be taken up readily by the wind.

32884——5

The light which the southern origin throws on questions of taxonomy has already been suggested, but it opens too large a field for elaboration here.

What is true of as great and diversified a family as the Filices may be expected to be equally true of some other large families. The Proteaceæ are a recognized case. It might well pay to examine the Rosaceæ, Rubiaceæ, and Orchidaceæ as to distribution and history.

Finally, it is fit that I disclaim anything more than I have said. Ferns existed well over the world longer ago than I would try to explain their presence as emigrants from Antarctica, and must be supposed to have maintained continuous existence elsewhere. This being so, the preponderance of ferns of apparent Antarctic origin in the world today is surprising indeed.

ILLUSTRATIONS

TEXT FIGURES

MARINE DIATOMS FOUND IN WASHINGS OF SEA WEEDS FROM FUKIEN COAST

By T. G. CHIN

Of the Marine Biological Station, University of Amoy, China

The 6 samples listed below were collected from Fukien Coast. Samples 1 to 5 were collected in Amoy and its vicinity, while sample 6 was collected from Haitan. Altogether 68 species were found in washings of different species of sea weeds; 15 species were newly recorded for China Coast; 3 brackish-water and 2 fresh-water species were found, since the inland fresh water easily reached the collecting ground. The new and rare species found will be described later.

Melosira moniliformis, Coscinodiscus lineatus, Coscinodiscus excentricus, C. radiatus, Arachnoidiscus ornatus, Grammatophora marina, and *Achnanthes brevipes* were the most common and most abundant diatoms obtained from sea weeds.

Sample 1.—Collected from Nantaiwu, south of Amoy, April 23, 1936. Ten species were found.

Sample 2.—Collected from Nantaiwu, south of Amoy, July 18, 1936. Thirteen species were found.

Sample 3.—Collected from Tseng Shu An, eastern coast of Amoy Island, June 5, 1936. Twenty-one species were found.

Sample 4.—Collected from Kulangsu, southwest of Amoy, October, 1937. Thirty-two species were found.

Sample 5.—Collected from Song Su, west of Amoy, June, 1937. Twenty-five species were found.

Sample 6.—Collected from Ox Mountain Light House, Haitan, May 12, 1937. Thirty-four species were found.

DIATOMS FOUND

MELOSIRA JUERGENSI Agardh.

Found in samples 5 and 6.

MELOSIRA GRANULATA (Ehr.) Ralfs.

Found in sample 5.

MELOSIRA MONILIFORMIS (Müll.) Agardh.

Found in samples 1, 3, 4, 5, and 6.

PARALIA SCULATA (Ehr.) Cleve.

Found in samples 1, 5, and 6.

PODOSIRA HORMOIDES (Mont.) Kützing.

Podosira hormoides (Mont.) Kützing, HUSTEDT (1928) 283, fig. 123.

Found in sample 4.

ACTINOCYCLUS EHRENBERGI Ralfs.

Found in samples 2 and 3.

ACTINOCYCLUS EHRENBERGI var. **CRASSA** (W. Sm.) Hustedt.

Actinocyclus Ehrenbergi var. *crassa* (W. Sm.) HUSTEDT (1929) 529, fig. 301.

Found in sample 3.

COSCINODISCUS SUBTILIS Ehrenberg.

Found in samples 2, 3, 4, and 5.

COSCINODISCUS LINEATUS Ehrenberg.

Found in samples 1, 2, 3, 4, and 6.

COSCINODISCUS EXCENTRICUS Ehrenberg.

Found in samples 2, 3, 4, 5, and 6.

COSCINODISCUS NODULIFER Schmidt.

Coscinodiscus nodulifer Schmidt, ALLEN & CUPP (1935) 116, fig. 9.

Found in sample 2.

COSCINODISCUS RADIATUS Ehrenberg.

Found in samples 1, 2, 3, 4, and 6.

COSCINODISCUS ASTEROMPHALUS Ehrenberg.

Found in sample 3.

COSCINODISCUS CURVATULUS Grunow.

Found in samples 4 and 5.

COSCINODISCUS MARGINATUS Ehrenberg.

Found in sample 4.

COSCINODISCUS JANISCHII Schmidt.

Found in samples 4 and 5.

COSCINODISCUS JONESIANUS var. **COMMUTATA** Hustedt.

Coscinodiscus Jonesianus var. *commutata* Hustedt, ALLEN & CUPP (1935) 117, fig. 11.

Found in sample 6. First record for China Coast.

COSCINODISCUS NOBILIS Grunow.

Found in sample 6.

CYCLOTELLA STRIATA (Kütz.) Grunow.

Found in samples 2 and 5.

CYCLOTELLA COMTA (Ehr.) Kützing.

Found in samples 3 and 4.

CYCLOTELLA STYLORUM Brightwell.

Found in sample 4.

ARACHNOIDISCUS ORNATUS Ehrenberg.

Arachnoidiscus ornatus Ehrenberg, V. HEURCK (1896) 506, fig. 255.

Found in samples 1, 3, 5, and 6.

ACTINOPTYCHUS UNDULATUS (Bail.) Ralfs.

Found in samples 3 and 4.

ASTEROMPHALUS FLABELLATUS Greville.

Found in sample 6.

TRICERATIUM ANTEDELUVIANUM (Ehr.) Grunow.

Tricheratium antedeluvianum (Ehr.) Grunow, HUSTEDT (1930) 810, fig. 472.

Found in sample 6. First record for China Coast.

TRICERATIUM FORMOSUM Brightwell.

Triceratium formosum Brightwell, HUSTEDT (1930) 891, fig. 481.

Found in sample 6.

BIDDULPHIA PULCHELLA Gray.

Found in samples 2, 3, 4, and 6.

BIDDULPHIA OBTUSA Kützing.

Found in samples 1 and 5.

BIDDULPHIA RETICULUM (Ehr.) Boyer.

Biddulphia reticulum (Ehr.) Boyer, ALLEN & CUPP (1935) 147, fig. 83.

Found in sample 6. First record for China Coast.

BIDDULPHIA AURITA (Lyn.) Brebisson.

Found in sample 6.

BIDDULPHIA AURITA var. OBTUSA (Kütz.) Hustedt.

Found in samples 1 and 5.

BIDDULPHIA LAEVIS fo. MINOR V. Heurck.

Found in sample 4.

FRAGILLARIA CROTONENSIS (A. M. Edwards) Kitton.

Found in sample 6.

RHABDONEMA ARCUATUM (Ag.) Kützing.

Rhabdonema arcuatum (Ag.) Kützing, V. HEURCK (1896) 360, pl. 12, fig. 487*a*.

Found in sample 6. First record for China Coast.

RHABDONEMA ADRIATICUM Kützing.

Found in samples 3, 5, and 6.

GRAMMATOPHORA MARINA (Lyn.) Kützing.

Found in samples 3, 4, 5, and 6.

GRAMMATOPHORA MARINA var. MACILENTA V. Heurck.

Grammatophora marina var. *macilenta* V. HEURCK (1896) 354, pl. fig. 480*a*.

Found in sample 4. First record for China Coast.

LICMOPHORA ABBREVIATA Agardh.

Found in samples 5 and 6.

CLIMASCOPHENIA MONILIGERA Ehrenberg.

Found in sample 2.

SYNEDRA GALLIONII Ehrenberg.

Found in samples 3, 4, 5, and 6.

ACHNANTHES BREVIPES Agardh.

Found in samples 2, 4, 5, and 6.

COCCONEIS DISRUPTA Greg.

Cocconeis disrupta Greg., V. HEURCK (1896) 290, pl. 8, fig. 343.

Found in samples 4, 5, and 6. First record for China Coast.

COCCONEIS MOLESTA Kützing.

Cocconeis molesta Ktz., V. HEURCK (1896) 290, pl. 29, fig. 823.

Found in sample 4. First record for China Coast.

COCCONEIS SCUTELLUM Ehrenberg.

Found in samples 1, 3, and 6.

NAVICULA CANCELLATA Donkin.

Found in sample 6.

NAVICULA IRIDIS (Ehr.) Cleve.

Navicula iridis (Ehr.) Cleve, DONKIN (1870) 31, pl. 5, fig. 7.

Found in sample 6. First record for China Coast.

NAVICULA FORTIS Greg.

Navicula fortis Greg., DONKIN (1870) 57, pl. 8, fig. 8.

Found in sample 6. First record for China Coast.

NAVICULA CRABRO Ehrenberg.

Found in sample 6.

NAVICULA ABRUPTA Greg.

Navicula abrupta Greg., DONKIN (1870) 13, pl. 2, fig. 6.

Found in sample 2. First record for China Coast.

TRACHYNEIS ASPERA Ehrenberg.

Found in samples 1, 3, 4, 5, and 6.

CYMBELLA ASPERA (Ehr.) Cleve.

Cymbella aspera (Ehr.) Cleve, V. HEURCK (1896) 146, pl. 1, fig. 35.

Found in sample 4. Fresh-water species.

AMPHORA SALINA W. Sm.

Amphora salina W. Sm., V. HEURCK (1896) 134, pl. 1, fig. 6.

Found in sample 6. First record for China Coast. Brackish-water species.

AMPHORA COSTATA W. Sm.

Amphora costata W. Sm., V. HEURCK (1896) 133, pl. 24, fig. 67.

Found in sample 2.

PLEUROSIGMA NAVICULACEUM Brebisson.

Pleurosigma naviculaceum Brebbisson, ALLEN & CUPP (1935) 157, fig. 103.

Found in sample 4. First record for China Coast.

PLEUROSIGMA RIGIDUM W. Sm.

Pleurosigma rigidum W. Sm., V. HEURCK (1896) 251, pl. 6, fig. 265.

Found in sample 4. First record for China Coast.

PLEUROSIGMA NORMANII Ralfs.

Found in samples 3, 4, and 6.

PLEUROSIGMA ANGULATUM Ehrenberg.

Found in samples 3, 4, and 5.

GYROSIGMA BALTICUM W. Sm.

Found in samples 3 and 4.

SURIRELLA FASTUOSA Ehrenberg.

Surirella fastuosa Ehrenberg, V. HEURCK (1896) 372, pl. 13, fig. 583.

Found in samples 4, 5, and 6.

SURIRELLA FLUMINENSIS Grunow.

Found in sample 4.

CAMPYLODISCUS HODGSONII W. Sm.

Campylodiscus Hodgonii W. Sm., V. HEURCK (1896) 376, pl. 32, fig. 868.

Found in samples 4 and 5. First record for China Coast.

CAMPYLODISCUS (?) COCCONEIFORMIS Grunow.

Found in sample 2.

BACILLARIA PARADOXA Gmelin.

Found in sample 6.

NITZSCHIA SUBTILIS Grunow.

Nitzschia subtilis Grunow, V. HEURCK (1896) 401, pl. 17, fig. 552.

Found in sample 5. First record for China Coast. Fresh-water species.

NITZSCHIA PUNCTATA (W. Sm.) Grunow.

Found in sample 4.

NITZSCHIA SIGMA var. INTERCEDENS Grunow.

Nitzschia sigma var. *intercedens* Grunow, V. HEURCK (1896) 396, pl. 16, fig. 531.

Found in sample 3. Brackish-water species.

NITZSCHIA LORENZIANA (W. Sm.) Grunow.

Found in samples 1, 4, 5, and 6. Brackish-water species.

HANTZSCHIA MARINA (Donkin) Grunow.

Hantzschia marina (Donkin) Grunow, V. HEURCK (1896) 382, pl. 15, fig. 489.

Found in sample 2. First record for China Coast.

TRIVERBAL SPECIFIC NAMES

By C. X. FURTADO
Of the Botanic Gardens, Singapore

At the last Botanical Congress, Amsterdam (1935), Dr. A. Becherer proposed as follows:

> The names *Asplenium Trichomanes dentatum* L. Sp. Pl. (1753) 1080 and *A. Trichomanes ramosum* L. op. cit. 1082, must be rejected since they are liable to be confused with the name *A. Trichomanes* L. Sp. Pl. 1080. The valid names are *A. dentatum* L. (1759) and *A. viride* Huds. (1762).

Whereupon Dr. T. A. Sprague observed that:

> The names *A. Trichomanes dentatum* and *A. Trichomanes ramosum* are intrinsically invalid, since they were not published as *binary* combinations (see Art. 27).—SPRAGUE, Synopsis of Proposals (1935) p. 74.

I would suggest that Article 27 does not apply in this case, for surprising as it may be, the wording of Article 27, far from condemning triverbal specific names, actually provides a means whereby certain triverbal specific names may be transformed into valid biverbal ones. In fact, despite the spirit of the rules, there is no express condemnation of triverbal specific names having biverbal specific epithets as such, except when individually the specific names do not refer to two valid descriptions, one generic and the other specific, or when they are found in works "in which the Linnean system of binary nomenclature for species was not consistently employed." (Article 68, 4). But in this last case not only triverbal specific names but also biverbal names must be rejected.

In order to enable the reader the better to follow my contention I transcribe here Article 27:

> Names of species are binary combinations consisting of the name of the genus followed by a single epithet. If an epithet consists of two or more words, these must either be united or joined by hyphens. Symbols forming part of the specific epithets proposed by Linnæus must be transcribed . . . . . .

Proof that my interpretation of the wording of Article 27 is correct is found in the examples given under the same Article. For instance, in the case of symbols, Linnæus did

not use a hyphen between the symbol and the word preceding it, but in the examples the symbols are not only transcribed but the hyphens are added. Furthermore, the specific epithet in *Adiantum Capillus veneris* L. (1753), *Impatiens Noli tangere* L. (1753), or *Atropa Bella dona* L. (1753) consists of two separate words, but in the samples the epithets have been united or hyphened to make the names biverbals. Had Doctor Sprague's contention been right, *A. Capillus veneris, Impatiens Noli tangere,* and *Atropa Bella dona* ought to have been rejected as "intrinsically invalid" names. Also in "Species Lectotypicae Linnaei," printed in the 1935 rules, the Linnæan triverbals, *Bignonia unguis cati, Choix lachryma jobi, Strychnos nux vomica, Trigonella foenum graecum, Ipomoea pes tigridis,* and others, have been consistently transformed into biverbals either by hyphening or by uniting the two separate words in each of the specific epithets.

Now *Asplenium Trichomanes dentatum, A. Trichomanes ramosum, Adiantum Capillus veneris, Impatiens Noli Tangere,* and *Atropa Bella dona* were all published as specific names not only under identical conditions but also in the same book; namely, Species Plantarum, 1753; and so there is no reason why, for purposes of validity, the first two triverbal names should be treated differently from the last three. Consequently, *Asplenium Trichomanes dentatum* and *A. Trichomanes ramosum,* like the other three names, should be accepted as valid binary names and transformed into biverbals in accordance with the provisions in Article 27.

Whether or not it is advisable to allow a valid status to non-Linnæan triverbal specific names is a matter that should be considered by the future Congress; but in arriving at such a decision consideration must be given to the question whether it is desirable to reject as invalid names like *Xanthophytum Johannis Winkleri* Merr.[1] and *Tibouchina Campos Portoi* Brade.[2] If, on the other hand, the omission of the hyphen is taken as a typographic or orthographic error, such biverbal generic names as *Chamae Filix* Hill, *Filix Foemina* Hill, *Adiantum album* Hill, *Capillus veneris* Hill, or multiverbal or phrase names of species, might be taken as valid, creating thereby a

[1] Mitt. Inst. Hamburg. Bot. 7 (1937) 271.

[2] Arch. Inst. Biol. Veget. Rio de Janeiro 4 (1938) 73.

necessity either for effecting many nomenclatural changes or for making special decisions to prevent those changes.[3]

In my opinion difficulties such as the above may be satisfactorily obviated both by adopting the distinctions between binary, binomial, and biverbal names given by me in this Journal [4] and by invalidating all binary binomials which are not biverbal, validity being allowed to biverbal specific epithets that occur as exceptions in papers that have in general fulfilled the rule.

[3] See also Farwell, Amer. Midl. Nat. 12 (1931) 233.
[4] Philip. Journ. Sci. 69 (1939) 467.

DETERMINATION OF THE PISCINE INTERMEDIATE HOSTS OF PHILIPPINE HETEROPHYID TREMATODES BY FEEDING EXPERIMENTS

PROGRESS REPORT [1]

By ANA VAZQUEZ-COLET and CANDIDO M. AFRICA

Of the Department of Parasitology, Institute of Hygiene and Public Health University of the Philippines, Manila

FOUR PLATES

In a previous paper(18) we published the results obtained in feeding experiments with 6 species of fish, namely, *Hepsetia balabacensis, Hemiramphus georgi, Ambassis buruensis, Mugil* sp., *Arius manillensis,* and *Clarias batrachus.*[2] Since then 11 more species of fish have been experimented with in the same way, and feeding experiments with *Arius manillensis, Ambassis buruensis,* and *Hemiramphus georgi* have been repeated. The results obtained constitute the subject of this report. The additional species of fish used this time were *Ophicephalus striatus,* locally known as *dalag; Glossogobius giurus, biá; Therapon plumbeus, ayuñgin; Gerris kapas, malakapas; Gerris filamentosus, malakapas; Creisson validus, biá ng sapa; Anabas testudineus, martinico; Ophiocara aporos, bangayngay; Pelates quadrilineatus, babansi; Teuthis javus, samaral;* and *Eleutheronema tetradactyla, mamale.*

Of the above fish, *Ophicephalus striatus, Therapon plumbeus, Anabas testudineus,* and *Opiocara aporos* are fresh-water fishes and the others are marine fishes, according to Dr. Deogracias Villadolid, ichthyologist of the Bureau of Science, Manila, who kindly identified them for us.

MATERIALS AND METHODS

The practice and technic described in the previous report were faithfully followed in the experiments reported in this paper.

[1] Aided by a special research grant from the Board of Regents, University of the Philippines.

[2] In the previous report this strictly fresh-water fish was accidentally listed as marine.

RESULTS

In Tables 1 to 14 we have recorded the results of our feeding experiments separately for each species of fish used by us.

REMARKS

Ten more piscine intermediate hosts (Tables 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, and 13) of Philippine heterophyid trematodes have been determined, and 4 species of heterophyids have been added to our previous list of 9 experimental heterophyids; namely, *Haplorchis pumilio* (= *Monorchotrema taihokui*), *Haplorchis taichui* (= *Monorchotrema taichui*), *Haplorchis sisoni* sp. nov., and *Stamnosoma formosanum*. Incidentally, one echinostomatid and one strigeid, represented by *Echinochasmus novalichesensis*(17) and an unidentified *Neodiplostomum* species, have also been recovered experimentally from 3 and 4 different piscine species, respectively (Tables 1, 2, 3, 8, and 12). Although *Echinochasmus* and *Neodiplostomum* are not heterophyids, we include them in this report for the sake of completeness. *Haplorchis sisoni,* a new species discovered in this series of experiments (Table 3), has been described by one of us (C.M.A.) in a separate paper. Our *Stamnosoma* specimens, recovered from four different piscine hosts (Tables 1, 2, 3, and 7), are all of one species, *ovigerous,* with two rows of circumoral spines (17 to each row), smoothly contoured testes, long intestine, and conspicuous ventral sucker, and are morphologically indistinguishable from mounted specimens of *Stamnosoma formosanum* obtained from Taihoku Medical College, Department of Parasitology, through the kindness of Prof. S. Yokogawa, to whom our thanks are due. They are entirely different from the two species of *Stamnosoma metacercaria* found by us in dissections of *Ambassis buruensis,* mentioned in our previous report, and which, up to this time, we have consistently failed to recover experimentally. The *Echinochasmus* specimens recovered in our experiments are undoubtedly young forms of one single species; one of them shows one solitary egg; they are indistinguishable from *Echinochasmus novalichesensis,* a bird parasite reported from the Philippines by Tubangui in 1932.(16) The *Neodiplostomum* specimens obtained by us are immature forms of one single species, the identity of which we have not yet determined. In our previous feeding experiments with *Arius manillensis* and *Clarias batrachus* we also recovered a similar, immature *Neodiplostomum* species, but

TABLE 1.—*Feeding experiments with metacercaria from Ophicephalus striatus (dalag).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	October 28, 1937, to January 5, 1938	43	91	January 7, 1938	*Haplorchis taichui*	949
					Haplorchis yokogamai	
					Neodiplostomum, immature	
Duck	October 27, 1937	1		October 28, 1937 [a]		0
Cat	January 21 to March 14, 1938	41	101	March 15, 1938	*Haplorchis taichui*	([b])
					Haplorchis tahokui	10
					Haplorchis calderoni	1
					Stamnosoma sp.	10
					Neodiplostomum, immature	
Control dog		0		December 10, 1937		0
Control duck		0		October 28, 1937		0
Control cat		0		February 1, 1938		0

[a] Died.

[b] Heavy infection.

TABLE 2.—*Feeding experiments with metacercaria from Glossogobius giurus (bia).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	October 29 to November 23, 1937	18	43	November 24, 1937	*Haplorchis calderoni*	14
					Stamnosoma sp.	13
					Haplorchis taikohui	½
Dog	December 4 to December 16,1937	8	80	December 17, 1937	*Haplorchis calderoni*	7
					Stamnosoma sp.	20
Do	February 11 to March 22, 1938	32	181	March 28, 1938	*Haplorchis calderoni*	(a)
					Stamnosoma sp.	(a)
					Echinochasmus sp.	1
Cat	June 15, 1938	1	(b)	June 17, 1938		0
Albino rat	do	1	(c)	June 19, 1938		0
Control cat		0		November 24, 1937		0
Control dog		0		December 6, 1937		0
Do		0		February 25, 1938		0
Control cat		0		June 10, 1938		0

[a] Many.
[b] One feeding of a single species of metacercaria which could not be recovered in previous experiments.
[c] One feeding of 99 metacercaria of the same species as in (b), which could not be recovered in previous experiments.

TABLE 3.—*Feeding experiments with metacercaria from Therapon plumbeus (ayuñgin).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	**October 25 to December 9, 1937**	28	398	December 10, 1937	*Haplorchis sisoni*	([a])
					Stamnosoma sp.	4
Cat	**January 21 to 31, 1938**	8	95	February 1, 1938	*Haplorchis sisoni*	([b])
					Stamnosoma sp.	1
					Neodiplostomum, immature	([b])
Dog	**January 24 to February 3, 1938**	9	140	February 4, 1938	*Haplorchis sisoni*	64
					Stamnosoma sp.	1
					Neodiplostomum, immature	([b])
					Echinochasmus, immature	2
Do.	**February 5 to 26, 1938**	17	218	February 27, 1938	*Haplorchis sisoni*	([b])
					Stamnosoma sp.	1
					Neodiplostomum, immature	([b])
					Echinochasmus sp.	1
Do.	**March 4 to August 5, 1938**	82	926	August 9, 1938	*Haplorchis sisoni*	52
					Stictodora manilensis	5
					Haplorchis yokogawai	6
					Haplorchis taihokui	8
Cat	**May 17 to August 16, 1938**	47	598	August 17, 1938	*Haplorchis sisoni*	60
					Haplorchis taihokui	10
Control dog		0		December 10, 1937		0
Control cat		0		February 1, 1938		0
Control dog		0		February 3, 1938		0
Do.		0		February 25, 1938		0
Do.		0		February 27, 1938		0
2 control cats		0		June 10, 1938		0
Control cat		0		June 17, 1938		0

[a] Too many to count.

[b] Many.

TABLE 4.—*Feeding experiments with metacercaria from Gerris kapas (malacapas).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	November 23, to December 6, 1937	5	48	December 8, 1937	*Haplorchis yokogawai*	121
					Heterophyes expectans	14
Control dog		0		December 6, 1937		0

TABLE 5.—*Feeding experiments with metacercaria from Gerris filamentosus (malacapas).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	January 24 to February 5, 1938	12	77	February 7, 1938	*Haplorchis calderoni*	4
					Stictodora manilensis	4
					Heterophyes expectans	6
Do	February 10 to March 29, 1938	35	234	March 30, 1938	*Haplorchis calderoni*	([a])
					Haplorchis taihokui	2
					Stictodora manilensis	([b])
					Heterophyes expectans	3
Control dog		0		February 3, 1938		0
Do		0		February 25, 1938		0
Do		0		February 27, 1938		0

[a] Very many.

[b] Many.

TABLE 6.—*Feeding experiments with metacercaria from Creisson validus.*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	March 2 to May 7, 1938	32	163	May 11, 1938	*Haplorchis calderoni*	105
Control dog		0		February 25, 1938		0
Do		0		February 27, 1938		0

TABLE 7.—*Feeding experiments with metacercaria from Anabas testudineus (martinico).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	February 11 to March 1, 1938	15	82	March 4, 1938	*Haplorchis calderoni* *Diorchitrema pseudocirrata* *Stamnosoma* sp.	([a])
Control dog		0		February 25, 1938		0
Do		0		February 27, 1938		0

[a] Light infection; most of the flukes were *H. calderoni*.

TABLE 8.—*Feeding experiments with metacercaria from Opiocara aporos.*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	February 11 to 14, 1938	3	5	February 25, 1938	*Echinochasmus* sp.	4
Control dog		0		do		0
Do		0		February 27, 1938		0

TABLE 9.—*Feeding experiments with metacercaria from Pelates quadrilineatus (babansi).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Dog	May 28 to August 3, 1938	34	408	August 4, 1938	*Stictodora manilensis*	43
					Heterophyes expectans	10
					Haplorchis calderoni	18
Control dog		0		February 25, 1938		0
Do		0		February 27, 1938		0

TABLE 10.—*Feeding experiments with metacercaria from Teuthis javus (samaral).*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	May 6 to August 1, 1938	23	126	August 5, 1938	*Heterophyes expectans*	20
					Haplorchis calderoni	46
					Haplorchis taihokui	1
Control cat		0		June 13, 1938		0

TABLE 11.—*Feeding experiments with metacercaria from Eleutheronema tetradactyla (mamale).*

Experimental animal.	Date of feeding.	Number of feedings.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	February 8 to July 4, 1938	3	August 16, 1938	*Haplorchis calderoni*	7
Control cat		0	Do.		0

TABLE 12.—*Feeding experiments with metacercaria from Arius manillensis (canduli).*

Experimental animal.	Date of feeding.	Number of feedings.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	November 22 to 26, 1937	2	December 4, 1937	*Haplorchis yokogawai*	78
				Neodiplostomum, immature	6
Control cat	------	0	November 27, 1937	------	0

TABLE 13.—*Feeding experiments with metacercaria from Ambassis buruensis.*

Experimental animal.	Date of feeding.	Number of feedings.	Number of fish used.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	May 16 to August 24, 1938	32	296	August 26, 1938	*Stictodora guerreroi*	19
					Heterophyes expectans	7
					Stictodora manilensis	8
					Haplorchis taihokui	8
					Haplorchis calderoni	7
Control cat	------	0	------	June 8, 1938	------	0

did not include it in the report because it is not a heterophyid. For the sake of completeness, however, we include it also in the present account. Two species of *Neodiplostomum* have been recorded in the Philippines; namely, *N. aluconis* Tubangui, 1933,(17) and *N. larai* Refuerzo et al., 1937.(15)

TABLE 14.—*Feeding experiments with metacercaria from Hemiramphus georgi.*

Experimental animal.	Date of feeding.	Number of feeding.	Number of fish used.
Cat	May 16 to September 2, 1938	34	181
Control cat	----------	0	----------

Experimental animal.	Date of dissection.	Flukes identified.	Number of flukes recovered.
Cat	September 6, 1938	*Stictodora guerreroi*	43
		Haplorchis calderoni	25
		Heterophyes expectans	9
Control cat	June 3, 1938	----------	0

In the experiment with *Hemiramphus georgi* (Table 14) previous findings are only partially duplicated, and no additional species are added. The experiment with *Ambassis buruensis* (Table 13) enriches our list for this fish with one more species of heterophyid, namely *Haplorchis pumilio* (= *Monorchotrema taihokui*), bringing up to 7 the total number of species of heterophyids so far recovered by us experimentally from this fish, and rounding up to 10 the species of heterophyid metacercaria which this fish harbors as second intermediate host. The experimental recovery of *Haplorchis pumilio* six times from 6 different species of fish (Tables 1, 2, 3, 5, 10, and 13) now for the first time definitely establishes its presence in this country. *Haplorchis taichui,* recovered in this series of experiments from one fish (Table 1) has already been reported from the Philippines by Africa et al.,(1) who found it in the small intestine of dogs and man. Two more piscine hosts (Tables 5 and 9) for *Stictodora manillensis,* 8 more (Tables 1, 2, 5, 6, 7, 9, 10, and 11) for *Haplorchis calderoni,* 2 more (Tables 1, 4) for *Haplorchis yokogawai,* 1 more (Table 7) for *Diorchitrema pseudocirrata,* and 4 more (Tables 4, 5, 9, and 10) for *Heterophyes expectans* have been determined by the persent series of feeding experiments. *Hemiramphus georgi* (Table 14) and *Ambassis buruensis* (Table 13) are hereby once more experimentally con-

TABLE 15.—*Names of flukes recovered experimentally from various species of fish.*

Fluke.	*Ophicephalus striatus.**	*Glossogobius giurus.**	*Therapon plumbeus.**	*Gerris kapas.**	*Gerris filamentosus.**	*Creisson validus.**	*Anabas testudineus.**	*Ophiocara aporos.**	*Pelates quadrilineatus.**	*Teuthis javus.**	*Eleutheronema tetradactyla.**	*Hemiramphus georgi.*	*Ambassis buruensis.**	*Arius manillensis.*	*Clarias batrachus.*
1. *Stictodora guerreroi*	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—
2. *Stictodora manilensis*	—	—	—	—	+	—	—	—	+	—	—	—	+	—	—
3. *Haplorchis calderoni*	+	+	—	—	+	+	+	—	+	+	+	+	+	—	—
4. *Haplorchis sisoni* y	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
5. *Haplorchis yokogawai*	+	—	—	+	—	—	—	—	—	—	—	—	—	+	+
6. *Haplorchis pumilio* y	+	+	+	—	+	—	—	—	—	+	—	—	+	—	—
7. *Haplorchis taichui* y	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8. *Diorchitrema pseudocirrata*	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—
9. *Heterophyes expectans*	—	—	—	+	+	—	—	—	+	+	—	+	+	—	—
10. *Stamnosoma formosanum* y	+	+	+	—	—	—	+	—	—	—	—	—	—	—	—
11. *Neodiplostomum* sp.ⁿ	+	—	+	—	—	—	—	—	—	—	—	—	—	+	+
12. *Echinochasmus novalichesensis* ᵒ	—	+	+	—	—	—	—	+	—	—	—	—	—	—	—

firmed as piscine intermediate hosts of *Stictodora guerreroi, Haplorchis calderoni,* and *Heterophyes expectans,* and *Stictodora guerreroi, Stictodora manillensis, Haplorchis calderoni,* and *Heterophyes expectans,* respectively. And lastly, the present experiment with *Arius manillensis* once more shows that this fish is an intermediate host of *Haplorchis yokogawai* and a *Neodiplostomum* species.

SUMMARY

Table 15 summarizes the results obtained in the present series of feeding experiments. For completeness we have included in it all our previous findings with *Clarias batrachus.* The 6 trematode species marked "y," "e," and "n," respectively, are new additions to our list of experimental flukes. The asterisks indicate eleven new species of intermediate piscine hosts of Philippine heterophyids.

The existence of *Haplorchis pumilio* (= *Monorchotrema taihokui*) and *Stamnosoma formosanum* in the Philippines are herein reported for the first time. *Haplorchis sisoni,* a species new to science, discovered in this series of experimental feedings, has been reported in a separate paper by one of us (C.M.A.).

The richness and variety of Philippine fishes in trematode metacercaria, mostly heterophyid, are further made evident by the present experimental findings.

ACKOWLEDGMENTS

Thanks are due to Dr. Deogracias Villadolid, ichthyologist of the Bureau of Science, Manila, for his kindness in identifying the fishes used in this investigation, and to Drs. Pedro G. Refuerzo and Eusebio Y. Garcia for their generous coöperation.

BIBLIOGRAPHY

1. AFRICA, C. M., and E. Y. GARCIA. Heterophyid trematodes of man and dog in the Philippines, with descriptions of three new species. Philip. Journ. Sci. 57 (1935) 253–267.
2. AFRICA, C. M., and E. Y. GARCIA. Two more new heterophyid trematodes from the Philippines. Philip. Journ. Sci. 57 (1935) 443–448.
3. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Intestinal heterophyidiasis with cardiac involvement: A contribution to the etiology of heart failures. Philip. Journ. Pub. Health 2 (1935) 1–22.
4. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Heterophyidiasis. II. Ova in sclerosed mitral valves with other chronic lesions in the myocardium. Journ. Philip. Isl. Med. Assoc. 15 (1935) 583–592.
5. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Heterophyidiasis. III. Ova associated with a fatal hemorrhage in the right basal ganglia of the brain. Journ. Philip. Isl. Med. Assoc. 16 (1935) 22–26.

6. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Heterophyidiasis. IV. Lesions found in the myocardium of eleven infested hearts, including three cases with valvular enlargement. Philip. Journ. Pub. Health 3 (1936).

7. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Heterophyidiasis. V. Ova in the spinal cord of man. Philip. Journ. Sci. 62 (1937) 393–399.

8. AFRICA, C. M., E. Y. GARCIA, and W. DE LEON. Heterophyidiasis. VI. Two more cases of heart failure associated with the presence of eggs in sclerosed valves. Journ. Philip. Isl. Med. Assoc. 9 (1937).

9. AFRICA, C. M. An attempt to elucidate the filtration of eggs of certain heterophyid trematodes into the general circulation. Philip. Journ. An. Ind. 5 (1938) 187–201.

10. CHAN, H. T. A study of the Haplorchinae (Looss 1899) Poche 1926 (Trematoda: Heterophyidae). Parasit. 28 (1936).

11. CIUREA, I. Archives Roumaines de Parasitologie Experimentale et de Microbiologie (1, 2) 6 (1933).

12. FAUST, E. C., and NISHIGORI, M. The life cycles of two new species of heterophyids, parasitic in mammals and birds. Journ. Parasit. 13 (1926) 9–128.

13. GARCIA, E. Y., and P. G. REFUERZO. Two more new species of the genus Stictodora Looss, 1899, in the Philippines, with description of a new species. Philip. Journ. Sci. 60 (1936) 137.

14. KATSUTA, I. On a new trematode Monorchotrema yokogawai of which the mullet is the second intermediate host. Journ. Med. Asso. Formosa (Taiwan Ikagawai Sasshi) (2) 31: 40, 41.

15. REFUERZO, P. G. Neodiplostomum larai, a new trematode parasite of the cattle egret. Philip. Journ. Sci. 62 (1937) 137–141.

16. TUBANGUI, MARCOS A. Trematode parasites of Philippine vertebrates. V. Philip. Journ. Sci. 47 (1932) 392–394.

17. TUBANGUI, MARCOS A. Trematode parasites of Philippine vertebrates. VI. Philip. Journ. Sci. 52 (1933) 183, 184.

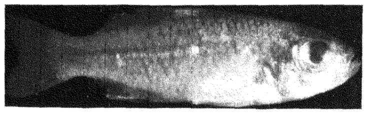
18. VAZQUEZ-COLET, ANA, and CANDIDO M. AFRICA. Determination of Philippine heterophyid trematodes by feeding experiments. Philip. Journ. Sci. 65 (1938) 293–302.

19. WITENBERG, G. Studies on the trematode family Heterophyidae. Ann. Trop. Med. and Parasit. 23 (1929) 131–239, 33 text figures.

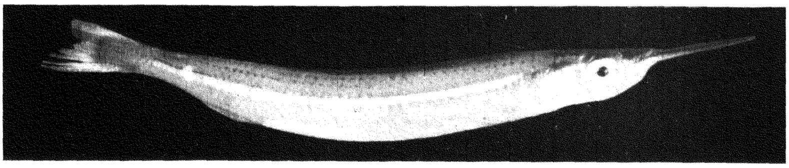
20. WITENBERG, G. Correction to my paper "Studies on the trematode family Heterophyidae." Ann. & Mag. Nat. Hist. 5 (1930) 412–414.

ILLUSTRATIONS

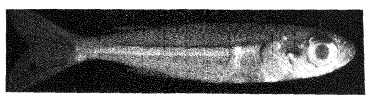
[The grapic scale in each figure represents 1 inch.]



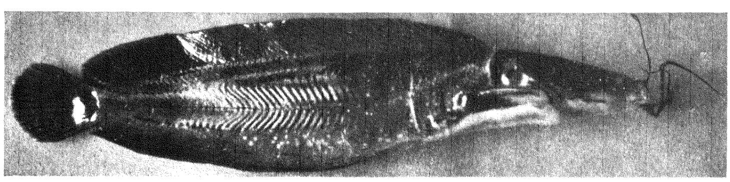
1



2



3



4

5

PLATE 1.

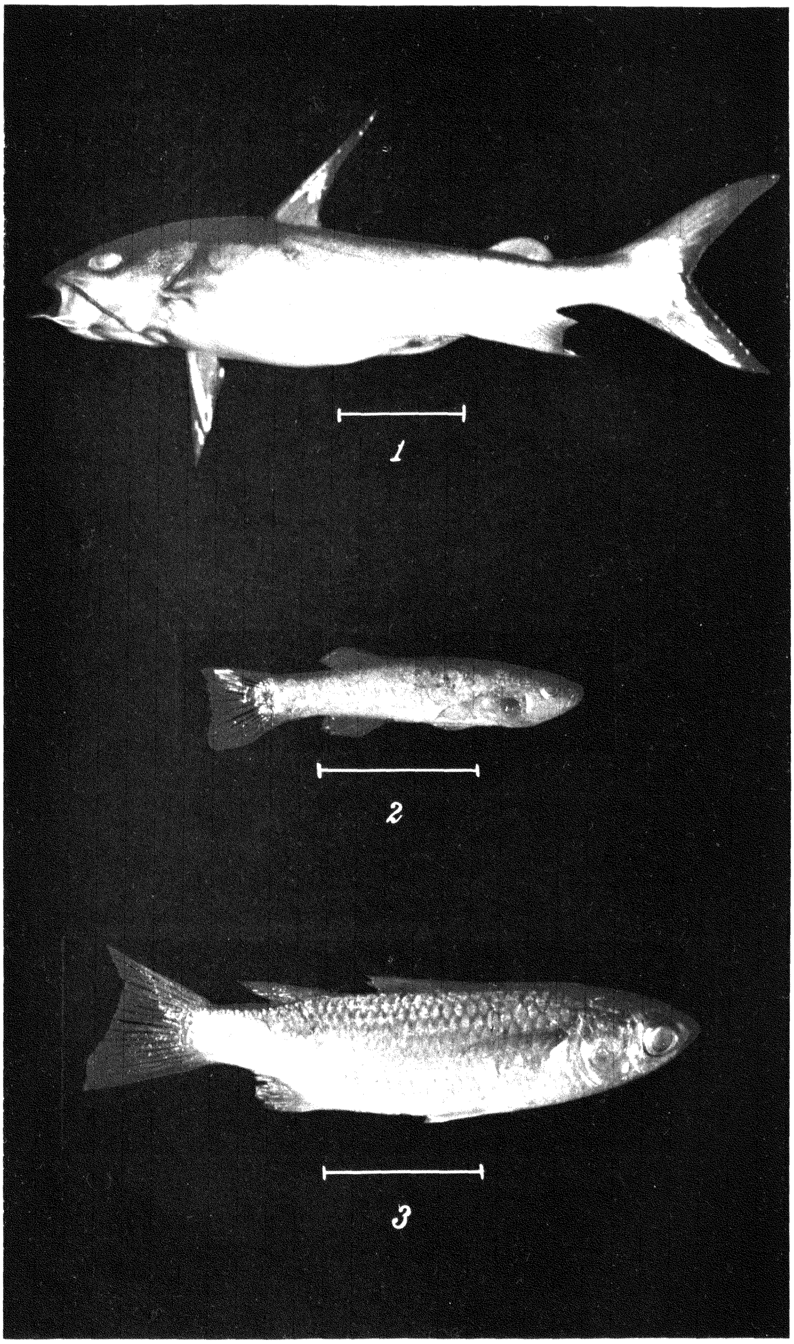


PLATE 2.

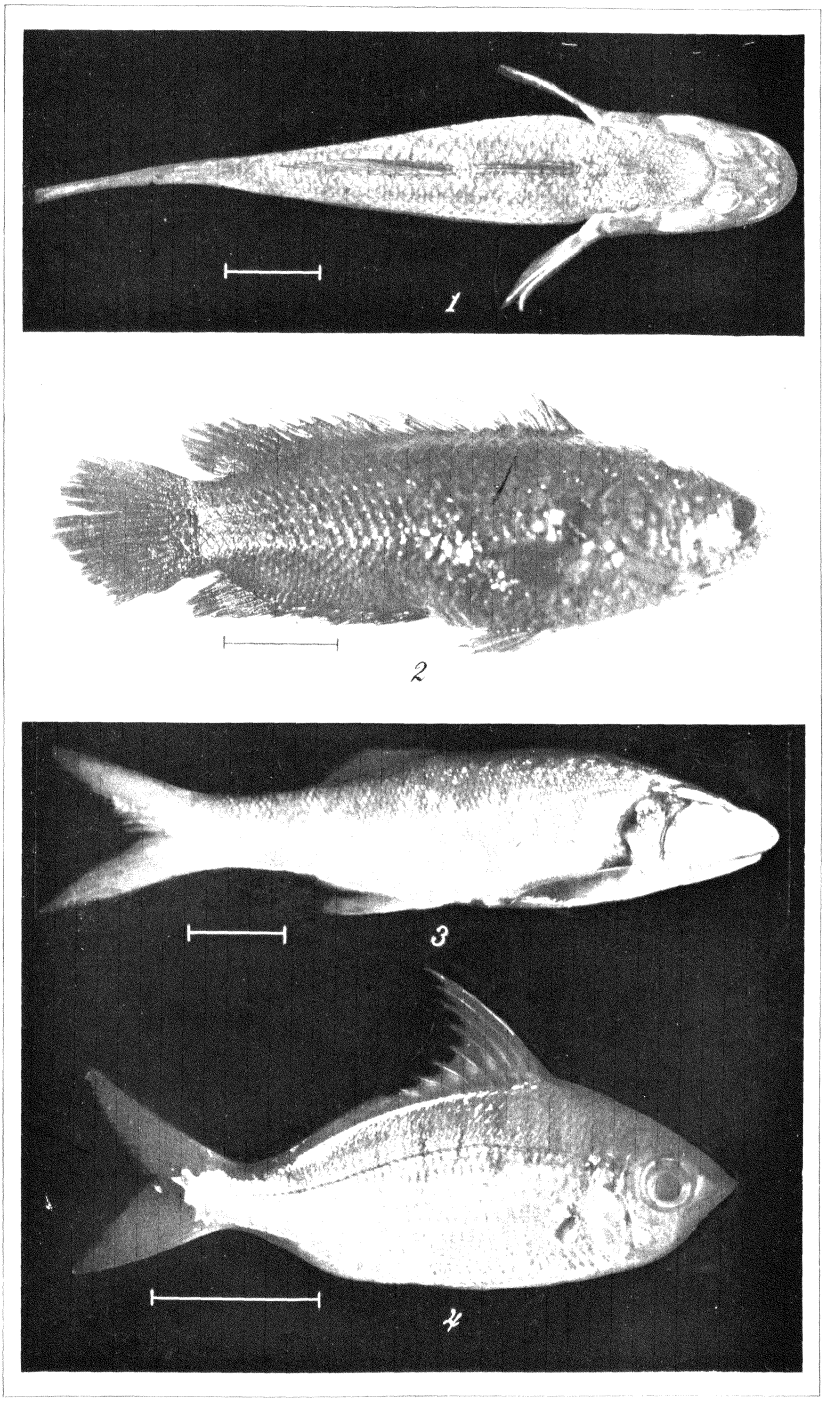


PLATE 3.

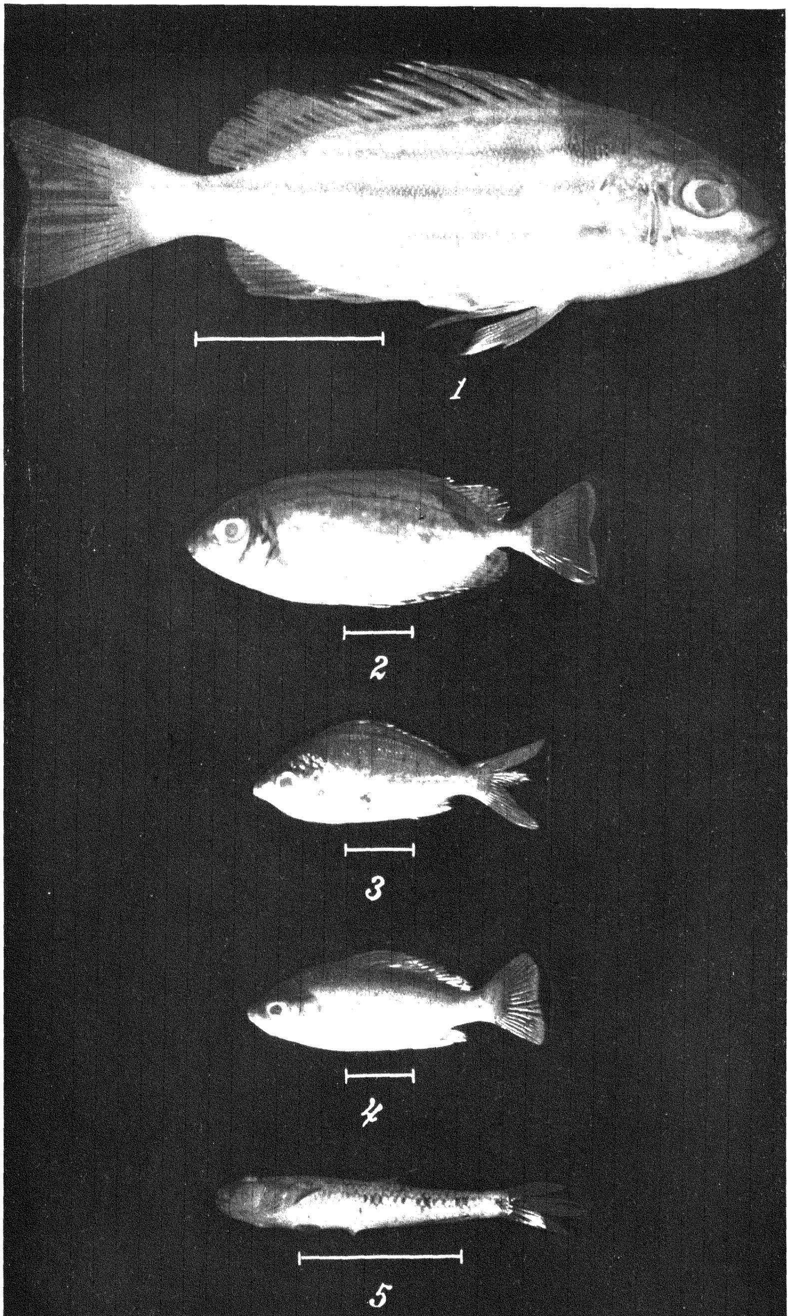


PLATE 4.

A RARE PARASITIC CRAB NEW TO PANGASINAN PROVINCE, LUZON

By GUILLERMO J. BLANCO and GUILLERMO L. ABLAN
Of the Division of Fisheries, Department of Agriculture and Commerce Manila

ONE PLATE

A. White (1846) described the genus *Xanthasia* to accommodate a female specimen of a single species of crab, *X. murigera,* of the family Pinnotheridæ. The origin of the material now deposited in the British Museum was vaguely given by White as "Philippine Islands." It was not until 1888 that de Man described the same species (two males and one female from *Tridacna*) from the material collected by Semper from Bohol and Burias Islands.

While working on the meat content of seventeen specimens of *Tridacna squamosa* Lamarck, collected from Lucap market, Alaminos, Pangasinan Province, September 23, 1938, the junior author obtained three gravid females and one male of *X. murigera* from the gills of these bivalves. Ninety-three years after the discovery of this species by White it is of geographical interest to note the new locality of this parasitic crab as being Luzon, Pangasinan Province, Alaminos.

Genus XANTHASIA White

XANTHASIA MURIGERA White. Plate 1, figs. 1 to 4.

WHITE, Ann. & Mag. Nat. Hist. **18** (1846) 176, pl. 2, fig. 3; DANA, U. S. Explor. Exped. Crust. **13** (1852) 384, pl. 24, fig. 6; DE MAN, Journ. Linn. Soc. London **22** (1888); BÜRGER, O. Zool. Jahrb. Syst. **8** (1895) 386, pl. 10, fig. 33; ESTAMPADOR, Philip. Journ. Sci. **62** (1937) 547.

Carapace with rough and irregular surface; margin, except frontal region, raised into an elevated ridge, curled around behind lateral knob on front of carapace. An elevated tubercle with lateral sharp edges and rough upper surface on middle of back of carapace. Two parallel longitudinal elevated keels between elevated tubercle and frontal region. Front of carapace projecting on each side, outside eyes; knobs present, making anterior part of carapace angular. Gravid female with extreme

bulging tail with prominent rounded keel down middle. Ambulatory legs short, cylindrical; claws thick, hooked, sharply pointed. Chela equal, small. Whitish in alcohol. The measurements and number of eggs of female specimens are given in Table 1.

TABLE 1.—*Measurements and number of eggs of female specimens.*

Specimen.	Carapace.		Number of eggs.
	Length.	Width.	
	mm.	*mm.*	
1	14	15	2,188
2	11	13	1,378
3	12	15	1,344

ILLUSTRATION

PLATE 1. XANTHASIA MURIGERA WHITE

[The graphic scale represents 1 inch.]

FIG. 1. Female, dorsal view.
2. Female, ventral view.
3. Male, dorsal view.
4. Male, ventral view.

32884——7

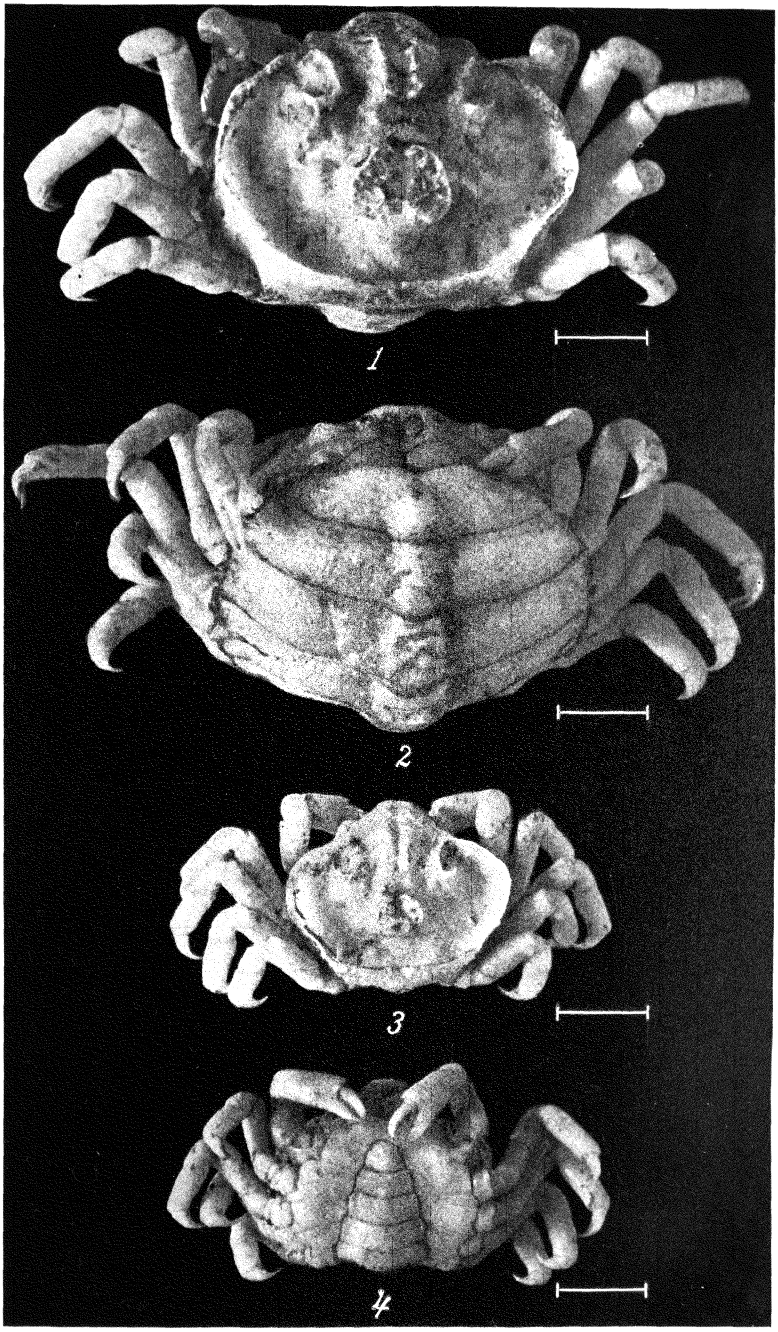


PLATE. 1. XANTHASIA MURIGERA WHITE.

VIABILITY OF THE COMMERCIAL OYSTER, OSTREA IREDALEI FAUSTINO

By DOMICIANO K. VILLALUZ

Of the Division of Fisheries, Department of Agriculture and Commerce Manila

THREE PLATES

Among the oysters raised in Bacoor Bay, Luzon, *Ostrea iredalei* Faustino is the most abundant. As early as 1935 oyster raisers using the hanging method of oyster culture began to recognize its superior quality. Requests for this species of oyster for propagation purposes have been numerous, and the Oyster Farm of the Division of Fisheries has tried to fill the demand to the best of its ability.

Oysters as food are beginning to be popular among Filipinos, because the public is being shown the sanitary conditions under which they are now being raised. In connection with the marketing of oysters, the important problem is to know how long they are capable of remaining alive outside of water, and to determine their viability, tests have been conducted in the Oyster Farm of the Division of Fisheries at Bacoor Bay.

DESCRIPTION

OSTREA IREDALEI Faustino. Plate 1, figs. 1 and 2.

Shell variable in shape, depending on mode of attachment; elongate, tongue-shaped, obliquely triangular or oblong. Outside of shell foliaceous, beak prominent. Left valve excavated, purple, right valve small, thin, flat, yellowish. Hinge toothless, inner margin of valve smooth. Interior of shell chalky white, muscle scar purple.

MATERIALS AND METHODS

Oysters raised in the Oyster Farm of the Division of Fisheries were utilized in these tests. Adult oysters about nine months old and of almost equal size were selected from among the bunches of oysters in the growing beds. Great care was taken not to destroy any part of the shell, especially the oyster "bill," so that

oyster liquor contained in the valves would not ooze out. Oysters used for observation were opened by means of a shucking knife which cuts and loosens the adductor muscles. The pericardial membrane was carefully opened to expose the heart and the heart beat observed. The sensitiveness of the tentacles of the mantle was tested by touching with the point of a dissecting needle. Throughout the experiment the following procedures were followed:

a. (1) Oysters contained in a sack and constantly moistened with sea water.
(2) Oysters contained in a sack and constantly moistened with fresh water.

b. (1) Oysters without mud contained in a wet sack.
(2) Oysters with mud contained in a wet sack.

c. (1) Oysters without mud contained in a dry sack.
(2) Oysters with mud contained in a dry sack.

d. (1) Oysters contained in a sack moistened from time to time and exposed to sunshine.
(2) Oysters contained in a dry sack and exposed to sunshine.

e. (1) Oysters with mud, exposed under shade.
(2) Oysters without mud, exposed under shade.

Three sets of tests were performed, the first June 27, the second July 5, and the third July 14, 1938.

OBSERVATIONS AND RESULTS OF TESTS

a. (*1*) *Oysters contained in a sack constantly moistened with sea water.*—The oysters treated were examined on the second and third days. It was observed that all of them were closed during these two days. On the second day seven oysters were carefully opened by cutting the strong adductor muscles. It was found that the valves were full of oyster liquor, the tentacles of the mantle were very sensitive, and the heart appeared to be beating normally. On the third day five oysters were opened. The adductor muscles were declining in strength and the valves were easily separated. The oyster liquor was comparatively lessened in amount, the tentacles of the mantle were not sensitive, and the heart beats were hardly perceptible.

(*2*) *Oysters contained in a sack and constantly moistened with fresh water.*—The oysters were still closed on the third day. Four oysters were carefully opened, and the valves were

observed to be very tight and the adductor muscles strong. The heart beats could hardly be discerned; tentacles of the mantle were sensitive and the valves filled with oyster liquor.

b. (*1*) *Oysters without mud contained in a wet sack.*—The oysters were examined on the second day and all were found closed. Five oysters were opened and carefully observed. It was found that the adductor muscles were strong; the valves filled with liquor; the heart beat rather slowly, and the tentacles were still sensitive. On the fourth day almost all of the oysters were found gaping. Oyster fluid was absent in all of them, the heart was no longer beating, and the tentacles of the mantle were not sensitive.

(*2*) *Oysters with mud contained in a wet sack.*—On the second day five oysters were opened. The adductor muscles were strong, the valves tightly closed, and oyster liquor was present inside. The heart beat normally and the tentacles of the mantle were sensitive. On the fourth day most of the oysters were gaping, and those closed were forced open. Their valves were easily separated and the adductor muscles very much weakened. The oyster liquor was almost consumed and the heart was no longer beating. The tentacles of the mantle were not sensitive.

c. (*1*) *Oysters without mud contained in a dry sack.*—On the fourth day the valves of oysters under this condition were found gaping. The oyster liquor was almost consumed in all of them, the heart was no longer beating, the tentacles of the mantle were not sensitive, and the valves were easily separated due to the weakening of the adductor muscles.

(*2*) *Oysters with mud contained in a dry sack.*—On the fourth day almost all of the oysters opened. Oyster liquor was absent in the gaping oysters while in those that were forced open this fluid was present only in small amounts. In both cases the heart had stopped beating and the tentacles of the mantle were no longer sensitive.

d. (*1*) *Oysters contained in a sack moistened from time to time and exposed to sunshine.*—The second day the oyster valves were found closed. Five oysters were carefully opened and observed. The valves were filled with oyster liquor, the heart was still beating, and the tentacles of the mantle were very sensitive. On the third day some of the oysters were gaping, and contained a very small amount of oyster liquor, and the heart was no longer beating. Some of the closed oysters were carefully opened and their valves found still filled

with fluid. The heart had stopped beating and the tentacles were no longer sensitive.

(*2*) *Oysters contained in a dry sack and exposed to sunshine.*—When the oysters were examined the second day, a small amount of oyster liquor was found in the valves, and the heart was beating very slowly. The tentacles of the mantle were sensitive. On the third day most of the oysters were gaping. Oyster liquor was absent in the valves and the heart had stopped beating. When the closed oysters were forced open the tentacles were no longer sensitive and the heart had stopped beating. Small amounts of oyster liquor were still present inside the valves.

e. (*1*) *Oysters with mud, exposed under shade.*—The second day five oysters were opened. The valves were full of oyster liquor, the heart beats appeared normal, and the tentacles of the mantle were sensitive. On the fourth day most of the oysters were gaping, were without oyster liquor, the heart was no longer beating, and the tentacles were not senstive. The closed oysters on opening were found to contain small amounts of oyster liquor, the heart was no longer beating, and the tentacles were not sensitive.

(*2*) *Oysters without mud, exposed under shade.*—The second day the oysters that were opened were full of oyster liquor, the heart was still beating, and the tentacles were very sensitive. On the fourth day most of the oysters were gaping while some remained closed. Both gaping and closed oysters were dead.

The results of the tests on viability are shown in Table 1.

DISCUSSION OF RESULTS

Oysters contained in a sack constantly moistened with sea water and those contained in a sack constantly moistened with fresh water were able to live an average of ninety hours. Oysters outside of water always keep their valves tightly closed so that the amount of either salt or fresh water that could enter them must have been very insignificant.

Oysters without mud and kept in a wet sack were able to live as long as those with mud kept in a wet sack. Both groups of oysters lived an average of ninety hours. Mud adhering to the surface of oyster shells seemed to have no great effect on viability.

Oysters under sunshine and moistened from time to time lived an average of sixty-four hours, while those under sunshine kept in a dry sack lived an average of sixty-three hours.

TABLE 1.—*Results of tests on viability of Ostrea iredalei.*

FIRST TRIAL

[Set 6:00 p. m., June 27, 1938.]

Procedure.	Dead. Date.	Time.	Number of hours alive.
	1938	*A. M.*	
Oyster wet with sea water	July 1	12:00	90
Oysters wet with fresh water	do	12:00	90
Oysters without mud in wet sack	do	12:00	90
Oysters with mud in wet sack	do	12:00	90
Oysters without mud in dry sack	do	11:30	89.5
Oysters with mud in dry sack	do	11:30	89.5
Oysters under sunshine in wet sack	June 30	8:00	62
Oysters under sunshine in dry sack	do	6:30	61
Oysters with mud exposed under shade	July 1	7:30	85.5
Oysters without mud exposed under shade	do	7:00	85
SECOND TRIAL [Set 2:00 p. m., July 5, 1938.]			
Oysters wet with sea water	July 9	12:00	94
Oysters wet with fresh water	do	12:00	94
Oysters without mud in wet sack	do	12:00	94
Oysters with mud in wet sack	do	12:00	94
Oysters without mud in dry sack	do	11:00	93
Oysters with mud in dry sack	do	11:00	93
Oysters under sunshine in wet sack	July 8	8:00	66
Oysters under sunshine in dry sack	do	6:30	64.5
Oysters with mud exposed under shade	July 9	8:00	89
Oysters without mud exposed under shade	do	7:30	88.5
THIRD TRIAL [Set 5:00 p. m., July 14, 1938.]			
Oysters wet with sea water	July 18	10:00	89
Oysters wet with fresh water	do	10:00	89
Oysters without mud in wet sack	do	10:00	89
Oysters with mud in wet sack	do	10:00	89
Oysters without mud in dry sack	do	9:30	88.5
Oysters with mud in dry sack	do	9:30	88.5
Oysters under sunshine in wet sack	July 17	10:00	65
Oysters under sunshine in dry sack	do	8:00	63
Oysters with mud exposed under shade	July 18	8:30	87.5
Oysters without mud exposed under shade	do	8:00	87

CONCLUSIONS AND RECOMMENDATIONS

1. *Ostrea iredalei* can live outside of water for an average of ninety hours.

2. The cooling effect of mud and water on the oyster is very insignificant in terms of viability.

3. High temperature shortens the life of oysters.
4. Shortening of the period of life of the oyster due to exposure under shade is insignificant.
5. Oysters in a sack can live under sunshine for two days.
6. It is safe to eat oysters forty-eight hours outside of water.
7. Oysters should always be kept out of direct sunshine.
8. The meat of oysters with open valves should never be eaten, as these oysters are usually dead and in the process of decomposition.

ILLUSTRATIONS

PLATE 1. OSTREA IREDALEI FAUSTINO

FIG. 1. With open valves.
2. About eight months old.

PLATE 2

Bunches of *Ostrea iredalei* Faustino, from the Oyster Farm of the Division of Fisheries.

PLATE 3

Heaps of shells of *Ostrea iredalei* Faustino, used as cultch in the Oyster Farm of the Division of Fisheries.

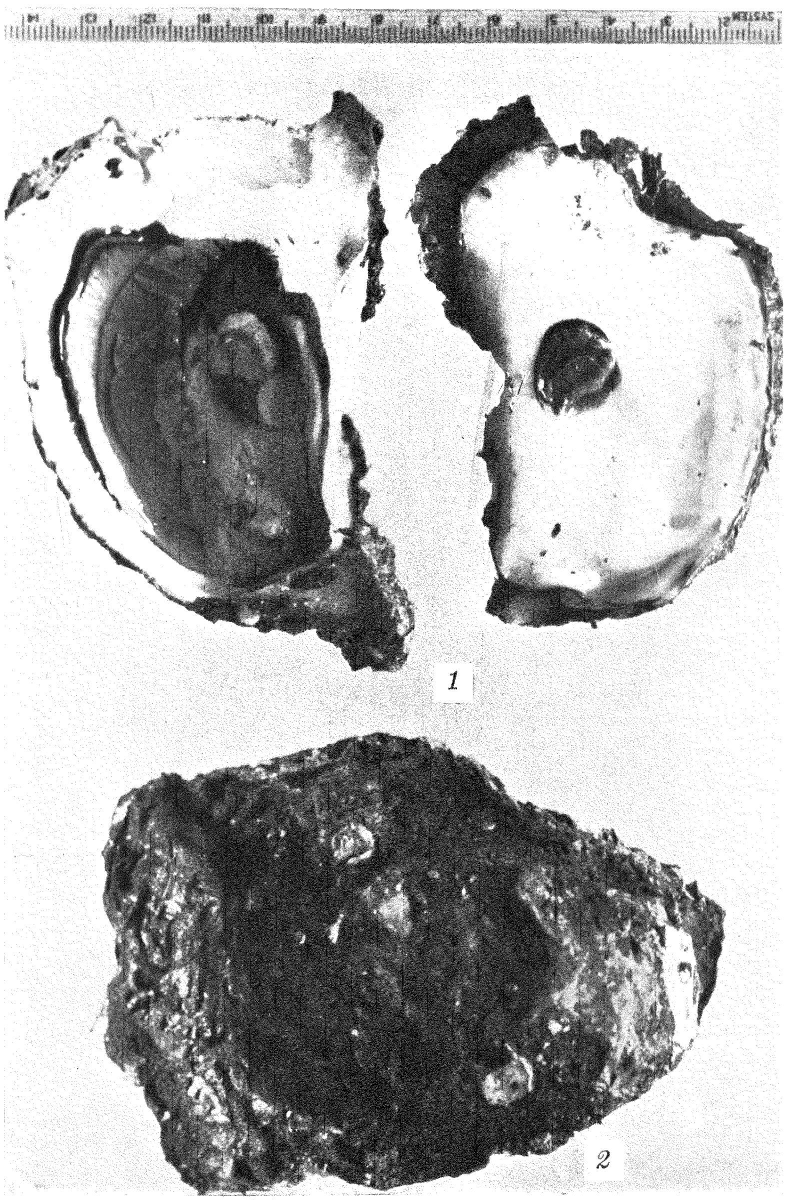


PLATE 1. OSTREA IREDALEI FAUSTINO.

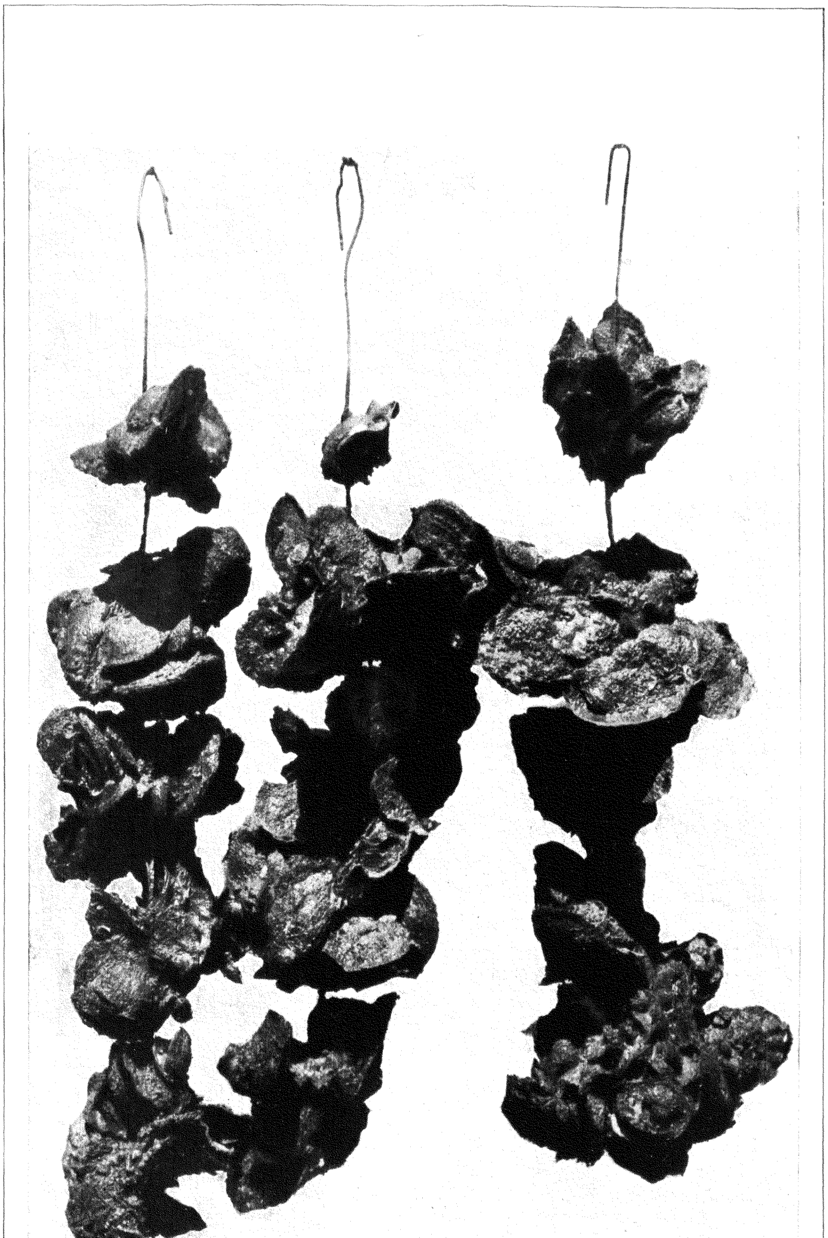


PLATE 2. OSTREA IREDALEI FAUSTINO.

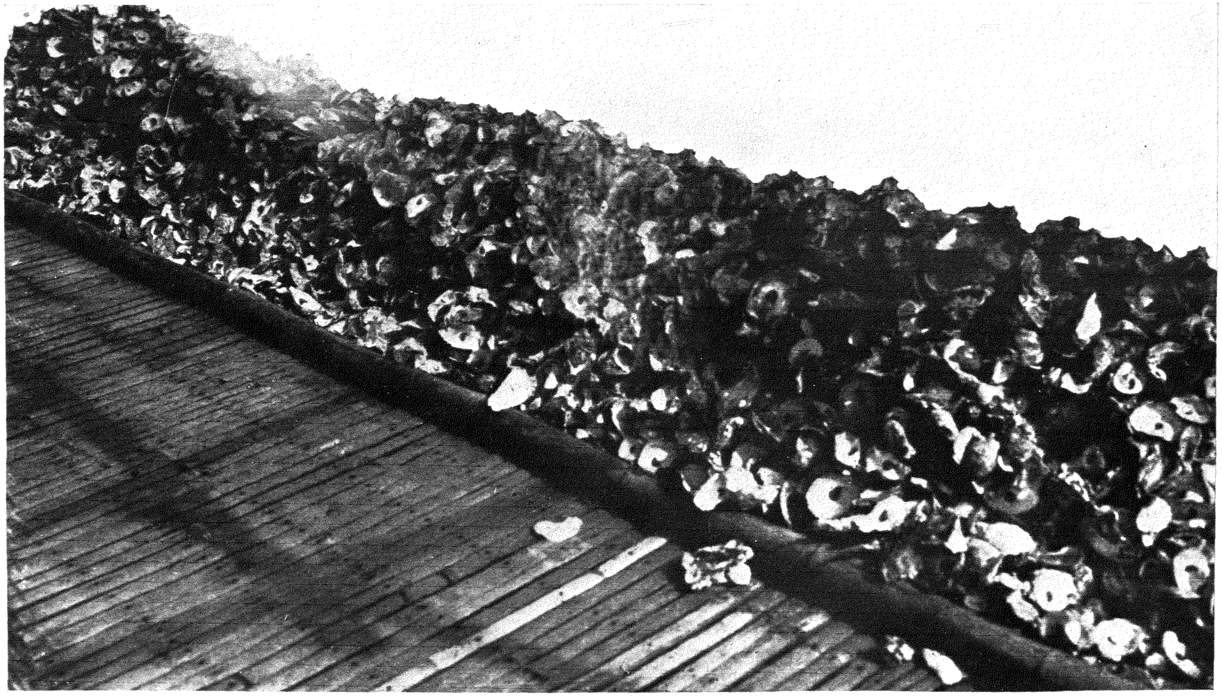


PLATE 3. OSTREA IREDALEI FAUSTINO.

BOOKS

Books reviewed here have been selected from books received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEWS

Practical Seismology and Seismic Prospecting. By L. D. Leet. New York, D. Appleton-Century company, incorporated, c1938. 430 pp., illus. Price $6.

This is the most interesting and comprehensive treatise on seismology that has appeared in English up to the present time. Chapter and section titles will indicate how thoroughly the field has been covered: Cause of Earthquakes; Distribution of Earthquakes; Elasticity and Elastic Waves; Instruments; Instrumental Observations; Effects of Earthquakes; Important Earthquakes of History; History of Seismology; Seismic Prospecting.

The chapters on Instruments and Instrumental Observations are very complete and practical. Considerable attention is given to the Benioff instruments, the latest and most promising in the field of seismology. The chapter on the Propagation of Elastic Waves emphasizes waves in the outer layers of the earth's crust because of their importance in seismic prospecting. The selection of important earthquakes is well made and each is written up in a most informative way. The selection is governed by actual seismic importance, and not entirely by loss of life or material damage. The classification of some large earthquakes by the Richter magnitude scale is interesting. Holden's dynamical equivalents of the Rossi-Forel scale are quoted but they are considerably higher than Cancani's values which are favored by engineers.

The history of seismology is given in nine pages, which contain an extraordinary amount of biographical and scientific data pertaining to the development of the science. The book terminates with two chapters on seismic prospecting which reduce to practice the principles given in the earlier chapters on elastic waves. A list of important patents is given on seismic prospecting and some court actions involved in connection with them.

There is a wealth of maps, diagrams and cuts which contribute greatly to an understanding of the matter. References are cited as footnotes.—W. C. R.

Manual of Roentgenological Technique. By L. R. Sante. Ann Arbor, Michigan, Edwards Brothers, Inc., 1938. 228 pp., front., illus. Price $4.50.

Although this book of Professor Sante represents a compilation of the work of others, as he has mentioned in his preface, it may be considered a great contribution to the list of books dealing with X-Ray technique. The simplicity of his language and the systematic procedure followed make the book understandable and useful to the vast army of students of radiology.

The roentgenological consideration, giving the hows and whys for every standard position selected in the radiography of the different parts of the body, is the most outstanding feature of the book, distinguishing it from other treatises on the same subject.

The volume is worth having because it will be of service not only to X-Ray technicians and radiologists but also to every physician who in his practice has to make X-Rays required in the analysis of his cases.

The book is profusely illustrated.—P. S. C.

The Soybean Industry. By A. A. Horvath. New York, The Chemical publishing Co. of New York, Inc., 1938. 221 pp. Price, $4.

The phenomenal development of soybean as an article of world commerce gave rise to a dearth of soybean literature. The present book seems to be the first attempt at assembling together in a brief and easily readable form scattered technical information about the soybean industry. Doctor Horvath, himself an eminent chemist and an authority on soybean manufactures, made a review of the more important literature on the chemistry of soybean and its products, and presents it as a popular and easily read publication.

The book is divided into 20 short chapters with a list of useful references. In the first chapters are discussed the methods of processing soybean into different products and the properties and industrial uses of such products. A brief account of the development of the soybean-oil industry is given, followed by a discussion of pressure oil milling versus solvent extraction. The various methods of oil extraction are discussed rather in detail. Also, the advantages and disadvantages of each are pointed out.

In the latter chapters an extended account of soybean oil, its properties, methods of refining, and industrial uses is presented. Similarly treated are the uses of soybean proteins. The methods of extracting soybean phosphatides and proteins are given in detail. The manufacture of plactics, adhesives, sizing materials, and others is well covered in the closing chapters. This book should be a good reference for all those interested in the soybean industry.—P. A. R.

Transactions of the American Institute of Mining and Metallurgical Engineers (Incorporated) Volume 127. Petroleum Development and Technology 1938. Petroleum Division. Papers and Discussions Presented Before the Division at Meetings Held at Los Angeles, October 1, 1937; Oklahoma City, October 7 to 9, 1937; New York, February 14 to 18, 1938. New York, American Institute of mining and metallurgical engineers, Inc., c1938. 744 pp., illus. Price, $5.

This volume maintains the usual high standard of publications of the A. I. M. E. in presenting a series of technical papers covering the progress of current research and development of Petroleum Engineering, including the papers presented at the sectional meetings of the Petroleum Division of the Institute, held during the year 1937–1938 at Los Angeles, Oklahoma City, and New York. Fundamental problems of oil production treated in separate papers by engineers from various fields in the United States include the "Spacing of oil wells" to obtain maximum recovery consistent with economic considerations, "Excessive pressures and pressure variations with depth of petroleum reservoirs in the Gulf Coast Region," "Pressure drilling operations at Kettleman Hills, and effect on initial production rates," and "Desalting of crude oils." The three most recently discovered notable oilfields in California are described by engineers operating in the respective fields. A chapter on engineering research includes papers on the various live and pertinent problems of oil technology introduced by one discussing the perennial question of the "Origin of petroleum."

The importance and interest of many of the papers are augmented by the inclusion, thereafter, of a stenographic report of the discussion of the particular issues involved in the respective papers.

Nearly one-half of the volume is devoted to oil production during the year 1937, in various oil-producing states of the Union, countries and oilfields. Thirty-one papers are included, giving a résumé of oil production by States and fields in the

United States and twenty-four reporting production and oil development in foreign countries.

A very brief chapter on "Refinery engineering for 1937" concludes the volume. Some papers include lists of references. There are many graphs and tables.—H. N. J.

Research and Statistical Methodology. Books and Reviews 1933–1938. By Oscar Krisen Buros, Editor. New Brunswick, Rutgers University Press, 1938. 100 pp. Price, $1.25.

Books and monographs on statistics and statistical research methodology, reviews of which are published elsewhere, are not always available to teachers or researchers. Buros, with the aid of Rutgers University, has accomplished an admirable piece of work to meet such a need, by gathering into one book of a hundred pages, scattered literature that makes publications on statistical subjects easily accessible.

The book under review contains (*a*) a classified index to books on research methodology and statistical methods; (*b*) "collated excerpts" of critical reviews of these books or monographs published recently; and (*c*) a comprehensive index to titles and authors separately of matters treated in the book. As the title of the book indicates, only books and monographs written and published recently, between January 1, 1933, and November 15, 1938, are included by the editor. Besides the most critical portions of the reviews of these books being excerpted and collated and published herein, full bibliographic information as to American and English prices and publishers is also given.

Reviews of statistical and research methodology books in all fields, such as actuarial mathematics, agriculture, biology, business, economics, education, engineering, forestry, history, marketing, medicine, psychology, sociology, vital statistics, and the like, from all available sources, published in Belgium, Canada, China, England, Holland, India, Scotland, South Africa, Sweden, the United States, and other countries, have been excerpted and collated in this book, a fact which therefore makes this volume a very handy guide in locating and selecting the particular type of book which the reader in statistics needs.

Although the present book is capable of enlargement by including standard books in statistics published earlier than 1933 and written in languages other than English, Buros and Rutgers University have given us a very valuable reference book on statistics and research methodology, the selection of such pub-

lished books being confined to a period in which new developments in the theory of statistics have taken place.—T. J. J.

Rubber-Growing: Elementary Principles and Practice. Compiled and prepared for publication by A. Moore. Kuala Lumpur, The Rubber Research Institute of Malaya, printed by Kyle, Palmer & Co., Ltd., 1938. 82 pp., illus. Price, 50 cents.

This article contains valuable information of the cultivation of rubber trees, the extraction and preparation of latex, and the protection of the trees from their various plant and animal enemies which rubber planters ought to be familiar with. It answers fully the long-felt need for a concrete guide in the selection of land suitable for rubber growing. It also treats of the right distance in planting as well as the correct way and the time of tapping the trees, the right procedure of making high quality sheet rubber, and the proper care and marketing of the product with a view to obtaining the maximum production at the minimum expense. This article is instructive as it presents fundamental principles underlying rubber culture in simple language free from the many technical terms which are often confusing to the layman.

While this publication is intended primarily for the enlightenment of rubber planters, particularly the small estate holders in Malaya, it is also of interest to persons interested in the proper care of plants and the conservation of the soil, like the agriculturist, the horticulturist, the landscape gardener, and the forester of other tropical countries. This manual contains photographs and diagrams.—M. G.

Tropical Nursing. A Handbook for Nurses and Others Going Abroad. By A. L. Gregg. With a Foreword by the Hon. Sir Arthur Stanley. London, Cassell and Co., Ltd. 199 pp., illus. Price, 6s.

This is a handbook that answers many of the questions and problems which almost daily confront the nurses working in tropical countries, more particularly those actively engaged in field work in remote and isolated places where the services of medical men are not generally available. It is precisely under such circumstances that the book fulfills a most necessary service, for in it the nurse as well as the layman finds a ready reference for information, advice, and direction to follow in coping with the different ailments and emergencies met with in the East.

As the title suggests, liberal space is devoted to the description of tropical diseases, giving their causes, the symptoms of

the different stages of their development, their treatment, and their prophylaxis. Malaria, dysentery, beriberi, and the different worm diseases which are most prevalent are discussed more in detail than the rest.

The book is interesting, instructive, and comprehensive. It is a wealth of knowledge to which field nurses, especially, should have access at all times for reference. Its size permits it to be carried conveniently in a pocket or in a bag.—E. M. A.

Some Methods for the Detection and Estimation of Poisonous Gases and Vapors in the Air. A Practical Manual for the Industrial Hygienist. By A. S. Zhitkova. Edited and with an introduction by Prof. S. I. Kaplun. Translated under direction of Joseph B. Ficklen. West Hartford, Connecticut, Service to Industry, c1936. 198 pp., illus. Price, $3.

This book is a valuable guide in the estimation of noxious materials found in industrial air. In 33 chapters it discusses the properties and estimation of substances usually dispersed in air in modern industrial plants. Some of the methods and apparatus described are new and ingeniously devised to solve some of the problems in this new field of applied chemistry. Micro-analysis, "specific" reaction (detection without isolation), and colorimetric and nephelometric procedures are frequently employed when the nature of the air dispersion does not permit the use of ordinary methods. Concise and helpful information on the occurrence and toxicity of each material treated is given at the beginning of each chapter. The manner of computation is clearly discussed, making it easy for even beginners to understand. This book is illustrated and includes a bibliography. It is primarily useful to industrial hygienists and chemists.

—R. T. S.

New and Nonofficial Remedies, 1938, Containing Descriptions of the Articles which Stand Accepted by the Council on Pharmacy and Chemistry of the American Medical Association, January 1, 1938. Chicago, American Medical Association, c1938. 590 pp. biblio., index, supplement.

The 1938 edition of this book fills a need always felt by the different professionals in the medical sciences. With the United States Pharmacopœia, the National Formulary in the United States, and the Extra Pharmacopœia in England as its predecessors, this book was published for the first time by the Council of Pharmacy and Chemistry established in 1905 by the American Medical Association. If this book, was, in its earlier

editions, a casual reference, it now has become useful and a necessity.

In the publication of this book rules were observed carefully so as to maintain perfect coördination with those for the United States Pharmacopœia and National Formulary started by the American Pharmaceutical Association years previous to 1888, when its first edition appeared. The enormous materials are well disposed in the book. Though they are discussed by groups, the various remedies are described in alphabetical order so that any substance is easily found.

The scope of this book is extensive, in the sense that it gives information on each remedy and a view of the different substances in actual use, including vaccines, sera, vitamins, hormones, and the like. Some of them may appear as a duplication of the United States Pharmacopœia or National Formulary. What characterizes this book is the complete and exhaustive list of all the pharmaceuticals and their manufactures. The acceptance of these preparations does not imply recommendation and the physicians should be aware of this distinction.

At the end of the book there are a general index, an index to distributors, and a bibliographical index of proprietary and unofficial articles not included in the text, although some of them are in vogue to some extent. To mention a few, we have optochin, the well-discussed sulphanilamide, and antuitrin.

The New Non-official Remedies should be on the desk of every physician. It should accompany the United States Pharmacopœia and National Formulary in the laboratory of every drug store. Chemists will find it an interesting reference.—M. V. R.

Practical Tree Surgery. By Millard F. Blair. Boston, The Christopher Publishing House, c1937. 297 pp., front., illus. Price, $4.

This book, the latest on tree surgery, embodies the most advanced and modern methods of practical tree surgery. The technical and practical knowledge with which the author is equipped makes him an authority on this subject and the most qualified to write on it. He discusses topics that are not only relevant but also essential to the broad aspects of the subject.

The inclusiveness and thoroughness of the book will strike the reader at once. The topics are grouped into thirty-two chapters, arranged in the most systematic manner. The author deals briefly with general characters and types of deciduous and coniferous trees, palms, and ornamental plants. The prin-

cipal insect and fungous enemies of these groups of plants, the injuries that these enemies produce, and the control measures for all of them, are discussed. A brief discussion is also devoted to beneficial fungi, the mycorrhiza. For the main subject the author discusses at some length tree structures and their function, principle of growth; trimming, planting, and pruning; types of braces and methods of bracing trees; cavities and their repairs, cavity bracing, filling, disinfecting, and water proofing; grafting and budding; propagation, natural and artificial; and pollination in relation to the development of new varieties.

It is noteworthy that throughout the discussion the author painstakingly avoids the use of highly technical terms without sacrificing thought or thoughts he wants to convey to the reader, so that any one with a limited knowledge of the fundamentals of biology can grasp without much difficulty the principles involved in the practice of tree surgery.

Although the book is designed for use in the American temperate zone, the principles laid down in it can be used as guides to tree surgery in other temperate and tropical countries of the world. In view of this the book is highly commended as an important reference, particularly for forest pathologists and horticulturists. The book contains illustrations and a short list of references.—E. F. R.

RECEIVED

BEADNELL, C. M. Dictionary of scientific terms as used in the various sciences. London, Watts & Co., 1938. 235 pp. Price, 1s.

BUROS, OSCAR KRISEN. Research and statistical methodology. Books and reviews 1933–1938. New Brunswick, Rutgers university press, 1938. 100 pp. Price, $1.25.

ELLIOTT, CHARLES N., and M. D. MOBLEY. Southern forestry. Atlanta, Georgia, Turner E. Smith & Co., 1938. 494 pp., front., illus. Price $1.60.

ELLIS, CARLETON, and MILLER W. SWANEY. Soilless growth of plants. Use of nutrient solutions, water, sand, cinder, etc. New York, Reinhold publishing corp. 1938. 155 pp., front., illus. Price, $2.75.

GUSTAFSON, A. F. Handbook of fertilizers their sources, make-up, effects and use. New York, Orange Judd publishing co., inc., 1939. 3d ed. 172 pp., illus. Price, $1.75.

KALICHEVSKY, VLADIMIR A. Modern methods of refining lubricating oils. American chemical society monograph series. New York. Reinhold publishing corp., 1938. 235 pp., illus. Price, $6.

LEET, L. D. Practical seismology and seismic prospecting. New York, D. Appleton-Century co., inc., c1938. 430 pp., illus. Price, $6.

LONG, W. BAYARD, and JACOB A. GOLDBERG. Handbook on social hygiene. With a foreword by Edward L. Keyes. Philadelphia, Lea & Febiger, 1938. 442 pp., illus. Price, $4.

NICOL, HUGH. Plant-growth-substances. Their chemistry and applications, with special reference to synthetics. London, Leonard Hill ltd., 1938. 108 pp., illus. Price, 3s 6d.

SHARPE, C. F. STEWART. Landslides and related phonemena. A study of mass-movements of soil and rock. New York, Columbia university press, 1938. 137 pp., illus. Price, $3.

The Textile manufacturer year book 1938. London, Emmot & company, ltd. "The Textile manufacturer" office. Japan: Maruzen co. ltd., Tokyo, Osaka, Kyoto, Yokohama, Nagoya, Fukuoka, Sendai, Sapporo, Kobe. 524 pp., illus. Price, 3s 6d.

WATTS, RALPH L., and GILBERT SEARLE WATTS. The vegetable growing business. New York, Orange Judd publishing corp., inc., 1939. 549 pp., front., illus. Price, $3.50.

WRENCH, G. T. The wheel of health. London, The C. W. Daniel co., ltd., 1938. 146 pp., front. Price, 6s.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 70 NOVEMBER, 1939 No. 3.

THE ODONATA OF THE PHILIPPINES, II

SUBORDER ZYGOPTERA

By JAMES G. NEEDHAM and MAY K. GYGER
Of Cornell University, Ithaca

TWELVE PLATES AND TWO TEXT FIGURES

In the slender Odonata, commonly called damselflies, the wings of the two pairs are similar in form and elevated in repose. The head is transversely elongated, its outer prominences capped with hemispherical eyes. The abdomen in the male is equipped at the tip with two pairs of clasping appendages, and in the female always with an ovipositor beneath the terminal segments.

In venation nodus and stigma are as in the Anisoptera, but the relations of the veins behind the arculus are very different. Instead of triangle and supratriangle there is a quadrangle (text fig. 3, *4*, *6* to *10*) that is, the morphological equivalent of the two together extending outward in the axis of the wing. Below the quadrangle is a subquadrangle that is likewise the equivalent of the anisopterous subtriangle plus the space extending from it proximally to the anal crossing (Ac). The outer ends of the quadrangle and the subquadrangle are thus brought into line, forming a transverse brace two cells long that join veins M_4 and A. This connective is often a convenient mark. It is called the medioanal link (ma).

The nymphs of the Zygoptera are slender; often very slender, especially in the abdomen which does not contain a gill chamber, the gills being external. Generally there are three gill plates at the end of the abdomen with their edges set ver-

tically and their surfaces traversed by a rich network of respiratory tracheoles. Sometimes they are inflated, and sometimes heavily chitinized and bearing spinous ridges that are better adapted for defense than for respiration. In *Rhinocypha* the middle gill plate is rudimentary and the others are wholly chitinized.

In addition there are single pairs of ventral gills under the sides of the abdomen on segments 1 to 7 in many nymphs of the Agrionidæ (Plate 11, fig. 139).

Below is a list of the Philippine zygopterous Odonata known to us, with the known nymphs marked as before. Those herein first described are marked with a star, those heretofore known with a dagger. A dagger in parenthesis indicates that the nymph of another species of the genus is known, not the species following it.

AGRIONIDÆ

Euphæa cora Ris.
(*)*Euphæa refulgens* Sélys.
Euphæa amphicyana Ris.
Heterophæa ruficollis Ris.
Heterophæa barbata Martin.
Cyclophæa cyanifrons Ris.
(*)*Neurobasis luzonensis* Sélys.
(!)*Vestalis melania* Sélys.
Cyrano unicolor Sélys.
Rhinocypha turconii Sélys.
Rhinocypha semitincta Sélys.
(*)*Rhinocypha colorata* Sélys.
(!)*Libellago asiatica* Sélys.
(!)*Micromerus lineatus* Burmeister.
Devadatta argyoides Sélys.
Devadatta filipina sp. nov.

CŒNAGRIONIDÆ

(!)*Lestes concinna* Sélys.
Lestes præmorsa Sélys.
(!)*Drepanosticta lymetta* Cowley.
Drepanosticta halterata Brauer.
Drepanosticta myletta Cowley.
Drepanosticta megametta Cowley.
?*Drepanosticta lestoides* Brauer.
Drepanosticta septima sp. nov.
?*Protosticta annulata* Sélys.
Caconeura integra Sélys.
Caconeura obsoleta Sélys.
(*)*Rhinagrion philippinum* Sélys.
Cœliccia dinoceras Laidlaw.
Cœliccia brachysticta Ris.
(*)*Prionocnemis serrata* Sélys.
Prionocnemis cornuta Brauer.
Prionocnemis atropurpurea Brauer.
Prionocnemis erythrura Brauer.
Prionocnemis hæmatopus Sélys.
Prionocnemis ignea Brauer.
Prionocnemis flammea Sélys.
Prionocnemis appendiculata Brauer.
Prionocnemis rubripes sp. nov.
Argiocnemis rubeola Sélys.
(!)*Agriocnemis femina* Brauer.
Agriocnemis velaris Sélys.
Agriocnemis lunulata Sélys.
Moroagrion danielli sp. nov.
(!)*Ceriagrion coromandelianum* Fabricius.
(*)*Pseudagrion pilidorsum* Brauer.
Pseudagrion crocops Sélys.
Pseudagrion azureum sp. nov.
Pseudagrion microcephalum Rambur.
Pseudagrion flavifrons sp. nov.
Pseudagrion evanidum sp. nov.
Cœnagrion pendulum sp. nov.
Ischnura senegalensis Rambur.
(†)*Ischnura elegans* Lind.
Pericnemis incallida sp. nov.
Pericnemis bonita sp. nov.

Pericnemis mcgregori sp. nov.
Pericnemis flavicornis sp. nov.
Pericnemis cantuga sp. nov.
?*Pericnemis glauca* Brauer.
?*Pericnemis lestoides* Brauer.
?*Amphicnemis furcata* Brauer.
Teinobasis dentifer sp. nov.
Teinobasis filiformis Brauer.
Teinobasis filum Brauer.
Teinobasis filamentum sp. nov.
Teinobasis corolla sp. nov.
Teinobasis nigra Laidlaw.
Teinobasis strigosa sp. nov.
Teinobasis olivacea Ris.
Teinobasis samaritis Ris.
Teinobasis recurva Sélys.

A good bit of the material representing the commoner species has been collected by students in the course of class field work, most of the duplicates coming from Los Baños and vicinity. To name the collectors of all specimens under our account of each of these species would take up far too much space; yet we wish to give credit to all who have helped. To that end we list the names of all those not elsewhere accredited with more valuable material, as follows: F. T. Aala, Claudio Adam, Anselmo P. Afalla, Faustino Agcaoili, Domingo M. Alava, Juan M. Alacon, Antonio C. Alberto, P. E. Alcala, J. Amores, E. V. Andaya, I. Ang, S. H. Angel, V. P. Antonio, T. A. Araneta, Isaac J. Aristorenas, M. Oro, R. Asibal, Pedro Asico, Alvaro Asuncion, M. Asuncion, P. Asuncion, L. Alicbusan, M. Avila, Generoso E. Baladad, Alfredo Barrera, D. Batenga, P. R. Bautista, S. Belo, Victor Belo, A. D. Benitez, L. Boongaling, T. C. Briones, C. B. Brizuela, G. Bumagat, F. Butac, P. Cabreros, R. Cabahug, Esteban Cada, I. Cadeliña, E. Caguicla, M. Caguicla, M. Camero, F. A. Caña, M. O. Cañeda, Leon Capinpin, S. R. Capco, E. Carandang, Pedro Carbonell, J. Casa, O. Casupang, I. Cayañga, M. Cero, Juan Cinco, Felicidad Chan, B. P. Clark, P. D. Collado, Amado F .Costes, Cenon Flor Cruz, P. V. Cruz, N. Cuevas, B. Dalid, Manuel Dinglasan, Federico Deximo, F. Dumaguing, A. C. Duyag, G. E. Edwin, Pilar V. Elayda, Pablo Enrile, D. Eamilao, P. Erce, S. Estocapio, A. Evangelista, L. D. Fadullon, T. Faysan, A. C. Felix, F. Felix, D. Fermin, F. Fermin, Andres B. Fernandez, Felix Flores, F. de Leon Flores, O. Fontanilla, W. Figueroa, P. C. Gabertan, J. Galapon, Celerino Gariando, R. B. Gines, J. Gironella, P. Gloria, J. Goguly, S. S. Gonzales, T. S. Gonzales, Rodolfo Guerrero, R. Guillem, Justino Guiyab, Fortunato Guzman, H. Hadden, J. T. Hernandez, A. Hilario, S. Inumerable, Onpel S. It, Kan Jalavicharana, Antero T. Jocson, Bartolome Javier, V. Juan, Elias Lantion, C. Las Marias, B. Legaspi, Isidro Macaspac, Vicente Madrigal, Felix Madrid, P. A. Magana, C. Magno, A. Malabayabas, P. D. Malang, Caesar Mamon, S. Manaig, C. G. Manuel, P. Macariola, Onofre Martin, Luciano

Marzan, Miguel Manresa, Jr., P. R. Manacop, I. Monje, A. Montallana, L. J. Neri, A. A. Ocampo, Roderigo Odes, F. Oliquino, B. Orig, V. Orque, P. Ortiz, M. Ouano, G. O. Palis, A. Palma, G. Pangga, C. Pangramuyen, N. Pepito, I. Perez, M. Plurad, R. Pugeda, G. Quiaoit, A. Ramos, M. Rebueno, F. Reformina, Restituto Reslerd, V. Revicencio, Fernando de los Reyes, J. Reyes, F. Rivera, S. R. Roque, A. Sabado, José Saddul, T. San Pedro, J. K. Santiago, Rudyardo Santiago, J. Santo Domingo, A. D. Santos, Dominador Santos, H. S. Savella, Theodore Schück, A. Serquenia, Bartolome Sison, C. B. Tantoco, Bartolome B. Tan, J. P. Tecson, P. Tiambeng, B. P. Tolentino, C. Valdez, V. Valenoba, Marcos Vega, Pedro Ventura, F. Verallo, I. Villafuerte, I. Villamoneda, Leo Yadao, Ramon Yanga, B. Yñiguez.

Key to the genera of Philippine Zygoptera.

ADULTS

1. Wings with more than five antenodal crossveins.............. 2. AGRIONIDÆ.
   Wings with but two antenodal crossveins.......................... CŒNAGRIONIDÆ.
2. Arculus nearer to nodus than to wing base and with its two sectors arising from its upper (anterior) end.. *Devadatta.*
   Arculus nearer to wing base than to nodus, and with its sectors arising from middle or nearer its lower end.. 3.
3. Vein M_4 not arched forward from end of quadrangle, M_4 and Cu_2 strongly divergent at edge of wing.. 7.
   Vein M_4 arched forward from end of quadrangle, M_4 and Cu_2 convergent at edge of wing.. 4. LIBELLAGINÆ.
4. Middle fork (Mf)[1] askew forward.. 5.
   Middle fork symmetrical or askew backward......................... *Micromerus.*
5. Stigma bordered behind by three cells.. *Libellago.*
   Stigma bordered behind by five or more cells.. 6.

[1] The arculus with the two sectors springing outward from it is always easily recognized, and the middle fork is always the first fork in the upper sector of the arculus.

FIG. 3. Venational characters of odonate wings. *1,* Principal veins and their connection; *2, Cordulegaster sayi,* wings; *3,* gomphine wing base, male; *4,* libelluline wing base; *5,* arculus and its sectors (M_{1-3} M_4); *6, Cyanocharis valga,* forewing; *7, Caliphæa consimilis,* part of wing base; *8, Telebasis salva,* forewing; *9, Telebasis salva,* part of wing base; *10, Anomalagrion hastatum,* stigma, female with brace vein *x.*

ABBREVIATIONS

A, Anal vein; *Ac,* canal crossing; *Al* or *al,* anal loop; *an,* antenodal crossveins; *ap pl,* apical planate; *ar,* arculus; *b,* basal subcostal crossvein; *br,* bridge; *Bs,* midbasal space, space before the arculus; *brs,* basal radial space; *C,* costa; *Cu,* cubitus; *g,* gaff (fused portion of vein Cu_2 and A_1); *h,* hypertriangular space; *M,* media; *m,* membranule, bordering the 3-celled anal triangle of the male hind wing; *ma,* medioanal link; *mf,* middle fork; *mpl,* median planate; *mr,* midrib (bisector of anal loop); *n,* nodus; *o,* oblique vein; *p,* patella; *q,* quadrangle; *R,* radius; *rm,* radial sector; *rpl,* radial planate; *s,* subtriangle; *Sc,* subcosta; *sct,* sector of the arculus; *sn,* subnodus; *sq,* subquadrangle; *st,* stigma; *t,* triangle; *tr pl,* trigonal planate; *u,* point at which petiolation (stalk) of wing base ceases; *x,* brace vein to stigma.

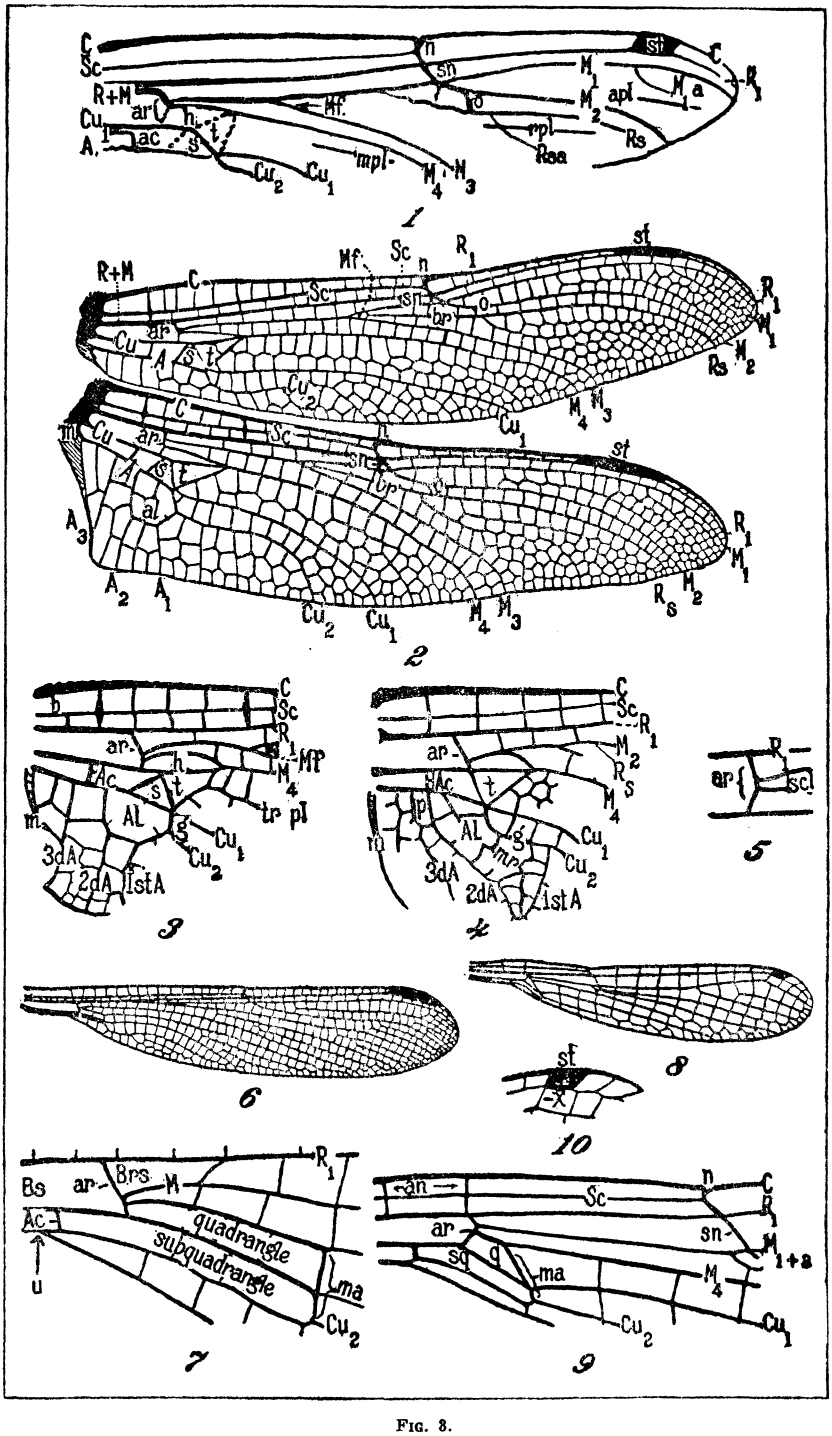


FIG. 8.

6. Nodus midway to stigma; antenodal crossveins about equal in number to postnodals .... *Cyrano.*
Nodus less than halfway out to stigma: antenodals far less numerous than postnodals .... *Rhinocypha.*
7. Stigma wanting or ill defined........ 8. AGRIONINÆ.
Stigma normally developed........ 9. EPALLAGINÆ.
8. Midbasal space with crossveins........ *Neurobasis.*
Midbasal space lacking crossveins .... *Vestalis.*
9. Veins M_4 and Cu_1 convergent to wing margin........ *Cyclophæa.*
Veins M_4 and Cu_1 strongly divergent to wing margin........ 10.
10. Sectors nearly straight; two rows of cells behind subquadrangle. *Dysphæa.*
Sectors strongly curved; one row of cells behind subquadrangle........ 11.
11. Subquadrangle with four or five crossveins; middle fork (*Mf*) halfway from arculus to nodus; cell increase between veins M_4 and Cu_1 begins far before level of nodus........ *Heterophæa.*
Subquadrangle with not more than two crossveins; middle fork less than halfway from arculus to nodus; cell increase between these veins beginning at about level of nodus........ *Euphæa.*

NYMPHS

1. Gills on abdominal segments 1 to 7; basal segment of antennæ shorter than segment 2........ EPALLAGINÆ, only *Euphæa.*
No gills on abdominal segments 1 to 7; basal segment of antennæ much longer than segment 2........ 2.
2. Basal joint of antennæ much shorter than entire remainder: median cleft of labium shallow, not reaching deeper than level of lateral lobes; gills represented by stout spines, tapering regularly from base, middle spine rudimentary........ 3. LIBELLAGINÆ.
Basal joint of antennæ about as long as all remaining segments together; median cleft of labium deep and wide; gills long and widened beyond base .... 4. AGRIONINÆ.
3. Rudiment of middle gill viewed from above a simple cone.... *Rhinocypha.*
Rudiment of middle gill viewed from above notched at tip......*Micromerus.*
4. Gills thickened, laterals strongly triquetral and spatulately dilated toward tip .... *Neurobasis.*
Caudal gills all thin and not dilated toward tip........ *Vestalis.*

AGRIONIDÆ

In this family are many of the larger damselflies with broader wings and more abundant venation. Among those of the Philippine Islands are some of the most brilliantly hued of living things. The rainbow tints and the gleaming green and gold of *Neurobasis luzonensis, Euphæa refulgens, E. amphicyana, Rhinocypha colorata,* and *Vestalis melania* are of surpassing beauty.

The three subfamilies here recognized represent extreme diversity in specialization, both as adult insects and as nymphs.

Genus SUPHÆA Rambur

This genus is represented in the Philippines by three good species; *refulgens* Sélys, *amphicyana* Ris, and *cora* Ris. The validity of *E. Semperi* Sélys is extremely doubtful; de Sélys questioned it. We have before us a series of *refulgens*, grading perfectly into the characters by which he separated *semperi*, and we are deterred from declaring it a synonym only by the fact that we have not seen the type specimen.

Among the hundred or more specimens of *refulgens* before us there are eight more or less definite types of color pattern, ranging from that of *semperi* through that of typical *refulgens* to one with the wings almost half hyaline. The eight variants shown in text fig. 4 grade into each other through degrees of obfuscation. The male appendages of all are practically alike, and all discoverable minute variants in them have been found in one locality (Los Baños).

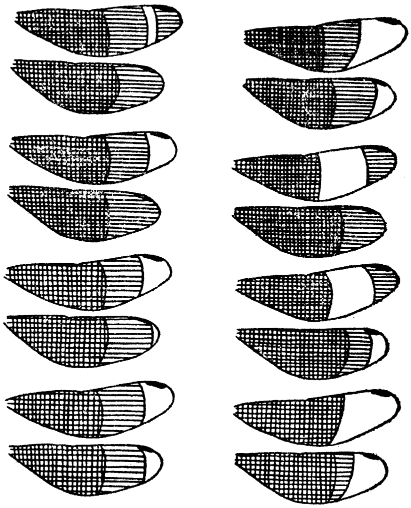


FIG. 4. Variation of wing coloration in *Euphæa refulgens* Selys. Crosshatching indicates metalic color; linear shading, nonmetalic obfuscation; and clear areas, hyaline.

Key to the species of Euphæa.

MALES

1. Wings wholly or partly infuscated.. 2.
   Wings hyaline .... *cora*.
2. Both wings dark in major portion.................................... *refulgens*.
   Front wings hyaline, hind wings dark.............................. *amphicyana*.

EUPHÆNA CORA Ris. Plate 12, figs. 156 and 157.

Euphæa cora RIS, Mitt. Münch. Ent. Ges. 20 (1930) 86, Mindanao, Surigao Province.

Length of hind wing of male 25.5 mm.

We have before us one specimen of *cora* from Zamboanga Province. It is easily distinguished from the other Philippine species by the hyaline wings. The tip of the abdomen is badly crushed, so our figure is of necessity a partial reconstruction.

The female has not been described.

EUPHÆA REFULGENS Sélys. Plate 11, figs. 136 and 140; Plate 12, figs. 152 and 153.

SÉLYS, Synop. Calopt. (1853) 53, male, Luzon, Manila; Mon. Calopt. (1854) 181; Bull. Acad. Belg. (2) 47 (1879) 375, female; tom. cit., 376 (as *E. semperi*, Manila).

Male, abdomen 35 mm; hind wing, 30.

Female, abdomen, 31 mm; hind wing, 31.5.

The males are gorgeous insects. The wings are brilliant metallic green, with violet reflections.

Forty females of *refulgens* from various localities agree with Sélys's description: Base of forewings obfuscated to a point about halfway between nodus and stigma, where there is a transverse band of milky white about three millimeters wide, thence hyaline to stigma, tip of wing dusky; hind wing entirely dark except for white band.

EUPHÆA REFULGENS Sélys. Nymph.

Length, 17 mm; gills, 7; abdomen, 8; width of head, 4; width of abdomen, 3.

A stocky brownish nymph with large, baggy, pilose caudal gills and seven pairs of long tapering ventral gills trailing under sides of abdomen. Head but little wider than long, flattish above, widest across eyes, slowly narrowed behind to the broadly rounded hind angles. The broad excavation of the occipital margin is sharply carinate where it fits against a dome-shaped projection of the prothorax. Relative lengths of segments of antennæ 5 : 10 : 6 : 7 : 6 : 5 : 4. Front of head below antennæ scabrous, above antennal bases slightly swollen. The deeply serrate outer edges of mandibles visible from above head.

Labium short and stout, its hinge reaching backward to mesothorax. Side margins of mentum convex, in outer half sharply serrate with appressed hairs arising singly, one under each tooth. Median lobe of mentum produced, dome-shaped, with a minute goblet-shaped median notch (open at the bowl, closed down the stem of the goblet), lateral border beset by microscopic retrose serrations. Lateral lobes small, beyond outcurving base nearly parallel-sided, outer margin beset with microscopic clavate hairs; movable hook stout; between its base and the short truncate end hook two terminal hooks, the inner two-fifths and the outer one-third as long as movable hook; inner margin of lobe almost smooth. Outer hump on mandible armed with about ten strong teeth, whose concave sides shelter single clavate hairs of possibly sensory function.

Prothorax depressed, disc shield-shaped, about twice as broad as long, narrowed in front to an anterior lobe that is set off by a shallow groove, and broadly rounded behind; beneath its

smooth and convex lateral margins the bulging sides thickly beset with short stout spinules. Synthorax and wings concolorous, the latter reaching rearward to end of abdominal segment 6. Legs concolorous, stout; femora flattened. On hind margin of middle and hind femora and tibiæ a line of long tawny hairs.

Abdomen rounded above, expanded at lateral margins into segmental lobes that overlie bases of corresponding ventral gills. These gills on segments 1 to 7, single, pale, tinged with purplish, each longer than width of abdomen, bent backward at base and thence regularly tapering to slender tips. The usual caudal gills (perhaps not gills in function) hairy especially at the ends, enormously swollen in their basal three fifths, thence suddenly contracted to slender taillike tips. Swollen portion ovoid, flattened on opposed surfaces as if by mutual compression.

The depressed front, flattened femora, short stout claws, and trailing position of the ventral gills, are all signs of a lotic source, and some of the numerous specimens are labelled "Molawin Creek, Los Baños, June 26, L. B. Uichanco". The others labelled "Los Baños" are perhaps from the same source.

EUPHÆA AMPHICYANA Ris. Plate 12, figs. 154 and 155.

Ris, Mitt. Münch. Ent. Ges. 20 (1930) 89, male, Mindanao, Surigao Province.

Male, abdomen, 38 mm; hind wing, 31.

We have four specimens of *E. amphicyana* from Zamboanga and Cotabato Provinces. The anal appendages are of the same general type as in *refulgens*, but are clearly distinct (Plate 12, figs. 154 and 155.).

HETEROPHÆA RUFICOLLIS Ris.

Ris, Mitt. Münch. Ent. Ges. 20 (1930) 90.

This species we have not seen. It appears to be known only from the male type specimen from Inyauan (Imugan?), Luzon. It is a rather large (hind wing 42 mm) black and red species. The rather narrow hyaline wings are tipped with brownish beyond the stigma. The species will be recognized by the bright red color of prothorax and abdomen, and by the venational characters stated in our key to genera.

Nymph unknown.

HETEROPHÆA BARBATA Martin.

Martin, Bull. Mus. Hist. Nat. (1902) 507, Luzon, Manila, June; Ris, Mitt. Münch. Ent. Ges. 20 (1930) 90.

This species we have not seen. It is known from a single male specimen. It is about the size of the preceding (abdomen,

55 mm; hind wing, 41). The color pattern of the prothorax is said to be more black than red, whereas in *H. ruficollis* it is more red than black.

CYCLOPHÆA CYANIFRONS Ris. Plate 12, fig. 158.

RIS, Mitt. Münch. Ent. Ges. 20 (1930) 81, figs. male and female, Binalaun, northern Palawan.

This species we have not seen. It is a blackish slender species of moderate size (male, abdomen 36 mm; hind wing, 30.5; female, abdomen, 30 mm; hind wing, 29). Plate 12, fig. 158, is a copy of Ris's figure of the remarkable process of the wall of abdominal segment 2 in the male. This figure, together with the venational characters given in our key, should be sufficient for the recognition of this species.

NEUROBASIS LUZONENSIS Sélys. Plate 13, figs. 159, 161, 162, 164, 165, and 176.

SÉLYS, Bull. Acad. Belg. (2) 47 (1879) 360, Luzon; An. Soc. Esp. Hist. Nat. 11 (1882) 19, as a race of *N. kaupii.*

One of the most beautiful of damselflies; body shiny green above, yellowish beneath, forewings subhyaline, hind wings in male dark with violet reflections above and green reflections beneath, in the female translucent golden amber. Unique among Philippine Zygoptera in having midbasal space of wings traversed by numerous crossveins.

One specimen was sent in 1918 from Magdalena, Luzon, by Dr. L. G. McConachie. Others have since been received at numerous times and from many collectors in Luzon and in Mindanao. *Neurobasis luzonensis* is undoubtedly a common lotic species.

NEUROBASIS LUZONENSIS Sélys. Nymph.

Length, 22 mm; antennæ, 12; gills, 15; hind femur, 10. Width, head 4 mm; abdomen, 3.

A remarkably elongate, long-legged, sprawling nymph with antennæ about three times as long as head, and with a labium that is mostly a rim for a wide diamond-shaped median cleft. Coloration mainly pale, marked with brownish. Head squarish, bare except for the four cornæ which are truncate at neck, with prominent eyes at middle of sides. Antennæ with an enormous basal segment, about twice as long as remaining six segments together, brownish, regularly tapering from base outward, square in cross section, clothed with microscopic, outwardly directed spinules. Labium slender, parallel-sided in its basal half, then suddenly widened to base of long, linear, lateral lobes, and divided more than half its length by an enormous wide median cleft that is encircled distally by the thin, con-

vergent, linear, incurving sides of the median lobe. The ends meet a little beyond level of tips of lateral lobes. Midway of their length each armed with a single marginal spinule. Movable hook slender, moderate in length, end hook half as long; two other hooks of terminal border intermediate between these in length.

Two broad pale stripes beginning on rear of head and extending back to wing roots, the brown median band between them divided by a pale middorsal line. Legs pale. Femora with two, tibiæ with three brownish bands. Basal half of femora marked with two lines of numerous pale brownish dots. Wings in this specimen reaching backwards only to abdominal segment 4.

Middle abdominal segments of equal length, end segments diminishing in length in about the proportions 10:8:7:6. Dorsum with a submarginal pale band each side and with four brown dots ranged across apical border, these becoming larger and more distinct to rearward. Gills brownish, with extreme tips paler and with obscure paler crossbands, two on lateral, one on median gill. Crossbands thin, translucent, laterals T-shaped in cross section, median crossband T-shaped. Crossbands widened from base almost to tip, median crossband most widened and about one-fourth shorter than laterals.

LUZON, Laguna Province, Mount Maquiling, Molawin Creek, June 9, 1932, altitude 200 feet.

VESTALIS MELANIA Sélys. Plate 12, figs. 166 and 167.

SÉLYS, Bull. Acad. Belg. (2) **35** (1873) 474, Luzon; ibid. **47** (1879) 360, Luzon, Mindanao; An. Soc. Esp. Hist. Nat. **11** (1882) 19, Mindanao; ibid. **20** (1891) 213, Dolores, Angat.

This very broad-winged damselfly (male, front wing, length, 35 mm; greatest width, 13) is wholly blackish in appearance until the light falls obliquely on the upper surface of the wings; then they fairly sparkle with the richest tints of metallic blue, with a touch of shiny green and golden at the extreme base. This species is easily recognized by the venational characters given in the key; the intercalary veins are all hitched on to the principal veins in such a manner that the latter appear to be repeatedly forked.

LUZON, MINDANAO, and SAMAR, 51 males and 39 females. (*H. C. Muzzall, A. C. Duyag, C. F. Baker, B. P. Clark, G. E. Edwin, R. Cabulig,* and *G. O. Palis.*

The nymph differs from all other known agrionine nymphs in having the three caudal gills thin and platelike, much as in the Cœnagrioninæ. It has been adequately described and

illustrated by Ris (1912) for *V. luctuosa*.[2] No nymphs of the Philippine species have come to us.

Genus CYRANO novum

Allied to *Rhinocypha* but differing markedly therefrom in stature, in proportions of wing, and in shape of face. Body very stout, swollen basal abdominal segments broadly depressed.

Eyes less wide apart than in *Rhinocypha*, the very thick prominence of face more broadly rounded and less projecting. Postclypeus wider than long, transversely ridged rooflike across middle, sloping forward down to its free border above labrum (which it does not surpass) and backward down into the deep furrow where it meets the frons.

Nodus much farther out in wing than in *Rhinocypha*, being halfway to stigma, ante- and postnodal crossveins approximately equal in number (postnodals often more than twice as numerous as antenodals in *Rhinocypha*). Front and hind wing margins parallel for about half wing length. Wide middle fork (Mf) strongly askew forward, vein M_2 arising a little (sometimes a cell length) beyond subnodus.

Type, *Rhinocypha unicolor* Sélys.

CYRANO UNICOLOR Sélys. Plate 12, figs. 149 and 150; Plate 20, fig. 290.

SÉLYS, Bull. Acad. Belg. (2) 27 (1869) 665, female, Manila.

Male, abdomen, 22 mm; hind wing, 27 to 28.

Female, abdomen, 20.5 mm; hind wing, 29 to 30.

This species appears not to have been described hitherto, but merely named, with measurements stated for a single female specimen in Dr. Hagen's collection and with remarks upon its large size. Name and measurements were communicated to de Sélys, who did not see the specimen.[3] The name doubtless refers to the clear wings—another anomaly for *Rhinocypha*. The species is well represented in the collections before us.

Head of adult male deep uniform black with a pair of cuneiform pale spots just lateral to paired ocelli and a pair of round pale spots on occiput (scarcely visible on old specimens). Labium, labrum, anteclypeus, frons, and occiput hispid.

Prothorax black, posterior lobe clad with long black hairs. Synthorax velvety black with a few touches of metallic violet. Dorsum, ventral half of sides, and venter hispid. Legs long,

[2] Tijd. v. Entomol. 55 (1912) 177, pl. 8.

[3] Our determination of this damselfly was corroborated by a comparison with the type kindly made for us by Dr. Nathan Banks.

slender, black, armed with an abundance of long spines. Wings hyaline, with a very small amount of obfuscation at extreme base. Veins black, stigma darkest brown. Ante- and postnodals about eighteen or nineteen each. Quadrangle traversed by three or four crossveins, subquadrangle usually by four or five.

Abdomen rather stout. In younger specimens it is slightly metallic brick-red on the dorsum of segments 2 or 3 to 8 with black lines on all carinæ; somewhat darker, more brownish red on venter; in very old specimens, entirely black with metallic violet reflections on dorsum. The strong lateral carinæ of segments 3 to 8 inclusive are slightly indicated on segment 2. A prominent dorsal ridge runs from the end of segment 2 to the middle of segment 9.

Anal appendages black; superior slightly dilated inwardly near tip. Inferiors much swollen basally, a little more than half as long as superiors, strongly toothed at tip, internally cleft with the supra-anal plate, vertically inclined, lying in cleft.

Teneral specimens much paler, on head and thorax a prominent pattern of dark brown and yellow. Two broad and conspicuous yellow stripes fill the wide vertical grooves that lie between the prominence of the face and the eyes. These stripes bare, thus standing in contrast with black hairy prominence, following eye margin upward, and narrowing to a point at level of ocelli. Three pairs of small isolated yellow spots in black on top of head; the larger pair between ocelli and eyes, the other two pairs in a single crossline farther back, inner pair minute.

Black dorsum of thorax divided by a yellow antehumeral stripe that is interrupted on both pro- and mesothorax. On sides of thorax two lines of yellow spots, three small elongate spots above, two of these beneath subalar carina, the third farther forward; two big angulate yellow blotches below, one of these extending down to middle coxa, the other up to base of hind wing. Venter mainly yellow, with brown on the front of each coxa, and in cross streaks between coxæ. Behind rear coxæ two more cross streaks of brown, rearmost streak in an area that is densely hairy.

Abdomen with large yellow spots on sides of two basal segments, only carinæ on segments 8 to 10 and appendages black. Remainder pale or with varying degrees of darkening according to age.

Female colored like younger male in head and thorax, but on abdomen narrow areas along longitudinal carinæ yellowish on segments 2 to 6, and round yellow spots persisting in middle of

black sides of segments 8 and 9. Appendages and apical segments otherwise black in mature specimens.

LUZON, Tayabas Province, Quezon Park, 12 males and 4 females (*F. Juan*); Zambales Province, Amiling, 1 male: Laguna Province, Mount Maquiling, 5 males and 3 females (*C. F. Baker*); Ube, 2 males (*McGregor* and *Celestino*); Los Baños, 7 males and 4 females; Mount Banahao, 5 males and 2 females (*G. A. Pangga*); Cavite Province, Indang, 1 male (*P. Erce*); Alfonso, 1 male (*M. Rosell*).

Nymph unknown.

Genus RHINOCYPHA Rambur

Of this large and widely distributed Oriental genus of small, broad-winged damselflies two brilliantly colored species, *R. colorata* and *R. semitincta,* are very common in the Islands, and a third, *R. turconii,* less common and known hitherto from the male only, is represented in the collections before us by specimens of both sexes.

Sélys[4] records a fourth species, *R. tincta,* from Manila. Kirby[5] does the same. These authors are probably in error, as most specimens collected in the East Indies were shipped from Manila or Singapore. *R. tincta* seems not to occur in the Philippine Islands.

The two first-named, *R. colorata* and *R. semitincta,* are very close together and possibly are not distinct, although from the material at hand we believe them to be. In the females of both the extreme tips of the hind wings are milky white—in *semitincta* the forewings also have this opaque edging. In *colorata* females the wings are a rather washed-out brownish with a narrow band of darker brown just behind the milky area, connected on the hind margin with a broader band of brown about halfway between nodus and stigma. The forewings of *semitincta* females are dark brown from well before the nodus to a point a little before the stigma, thence hyaline to the white tips; the hind wings are dark, lacking this clear area. The coloration of the wings of the males of *colorata* is quite variable, but it rarely starts as far proximad in the wings, or has such a pronounced angle in the middle of the wing as that of *semitincta.* The tips of the forewings of *colorata* nearly always have a lighter area, while the color is uniform in *semitincta.*

[4] Syn. Cal. (1853) 54.
[5] Cat. Neur. Odon. (1890) 114.

Usually, also, the metallic coloring in *semitincta* is much more brilliant.

The lustrous iridescence of the broad colored area of the wings—brilliant metallic blue changing to green and gold and purple—is very beautiful.

Key to the species of Rhinocypha.

1. Front wings colored .... 2.
   Front wings hyaline.. *turconii.*
2. Inner margin of colored area in wings of male with a strong reëntrant angle several cells proximad of nodus; abdominal segment 10 deeply excavate dorsally; wings of female dark brown.................... *semitincta.*
   Inner margin usually entirely distal of nodus and without a strong angle; abdominal segment 10 slightly excavate dorsally, wings of female pale brown .... *colorata.*

RHINOCYPHA TURCONII Sélys. Plate 12, figs. 147 and 148.

SÉLYS, An. Soc. Esp. Hist. Nat. 20 (1891) 215, male, Panay, Cebu.

Male, abdomen, 18 mm; hind wing, 23 to 25.

Female, abdomen, 17 mm; hind wing, 24.

This species is easily separated from the two following by the wing pattern. The forewings and the proximal two-thirds of the hind wings are hyaline with the distal third of the latter sharply marked off, black in the male, and pale brown in the female, hitherto undescribed.

Female.—Head black with yellow-cream markings as follows: A large triangular spot on base of each mandible, a similar spot on the posterolateral corners of snout, a narrow line against anterior margins of eyes, a pair of small round spots just behind and lateral to the paired ocelli, another similar pair behind and lateral to ocelli.

Prothorax black, with cream-yellow spots on sides. Synthorax black with a long slender dusky yellow humeral dash, followed in the same line with a small cuneiform spot, a broad basal yellow stripe starting on hind margin of middle coxæ and running back to abdomen. Legs black exteriorly, powdered with white on inside. Forewings subhyaline, saffron-stained to level of stigma, hyaline below and beyond it. Hind wings same as forewings to a point about halfway from nodus to tip of wing, from there on washed with brown with a large round clear spot in center of dark and a tiny tip of opaque white on most distal point of wing. Ante- and postnodal crossveins 12 : 27 and 13 : 18 in forewing and hind wing, respectively.

Abdomen black, with yellow band from thorax continued in a broken and diminishing line down the side—broken into a dash and a dot on segments 2 to 5, three medium dots on segment 6, and three very small dots on segment 7, absent thereafter. A ventral distal margin of yellow on segment 8.

Male.—Forewings wholly subhyaline with only a tinge of brown across extreme apical margin. Apical third of hind wings opaque blackish brown, sharply defined. Hind wings dilated in apical half, much broader than forewings, and tapering regularly from near base of stigma to base.

MINDANAO, Zamboanga Province, Kabasalan, 9 males (*H. C. Muzzall*). LUZON, Laguna Province, 1 male and 1 female, collector unknown; Mount Banahao, 1 male, *G. A. Pangga.*

RHINOCYPHA SEMITINCTA Sélys. Plate 12, figs. 145 and 146.

SÉLYS, Bull. Acad. Belg. (2) **27** (1869) 664, male and female, Moluccas; ibid. (2) **35** (1873) 491; An. Soc. Esp. Hist. Nat. **11** (1882) 20, Mindanao; ibid. **20** (1891) 213.

Male, abdomen, 17 mm; hind wing, 21.

Female, abdomen 18 mm; hind wing, 21.

MINDANAO, Cotabato Province, Kidapawan, 6 males and 2 females (*B. P. Clark*); Zamboanga Province, Kabasalan, 12 males and 17 females (*H. C. Muzzall*).

RHINOCYPHA COLORATA Sélys. Plate 11, figs. 131 to 135; Plate 12, figs. 141 to 144.

SÉLYS, Bull. Acad. Belg. (2) **27** (1869) 664, males, Luzon, Manila; ibid. (2) **35** (1873) 489; tom. cit., 490, as *R. frontalis;* ibid. (2) **36** (1873) 615 as *R. albistigma;* ibid. (2) **47** (1879) 395; An. Soc. Esp. Hist. Nat. **11** (1882) 19, Luzon, Cebu, Bohol, eastern Mindanao, up to 1,300 meters; ibid. **20** (1891) 214, Dolores and Sibul.

Male, abdomen, 16.5 mm; hind wing, 21.

Female, abdomen, 17 mm; hind wing, 21 to 24.

One thousand seven hundred males and females from practically all localities and collectors.

RHINOCYPHA COLORATA Sélys. Nymph (supposition).

Length, 12 mm; tail, 5; antennæ, 4; abdomen, 7.5; hind femur, 4.

Width, head, 3; abdomen, 3.

This smooth nymph has the body linear, moderately depressed, with banded appendages and spine-tipped abdomen. Head subtriangular, widest across rear of eyes, suddenly narrowed behind eyes to rounded hind angles and a deeply excavate occipital margin. On each hind angle is a prominent nipple-shaped

tubercle below which are scattered minute prickles. Antennæ brownish, with a pale ring on a long basal joint that nearly equals in length all joints that follow. Labium flat, its hinge reaching back to mesothorax; labial mentum evenly narrowed from lateral lobes backward to hinge; labial front border slightly produced and roundly bilobed. Three pairs of brown marks on its pale surface, one pair on lateral lobes externally, one pair at their bases, one pair at sides of median cleft. Movable hook on end of lateral lobe longer than any of four similarly curved terminal hooks below it. The innermost terminal hook is the end hook, which has a subtruncate tip. On the flat under surface of head beneath the eye runs a longitudinal carina that is beset with stout spinules.

Prothoracic disc brownish, with a broad median pale stripe, suddenly widened behind middle in a pair of prominent lateral tubercles, between which is a smaller pair of tubercles. Median pale stripe continued rearward to end of abdomen. Femora light brown, thrice ringed with paler; remainder of legs pale. Wing cases reaching rearward to middle of abdominal segment 6. Developing venation in wings with fourteen ante- and thirty postnodal crossveins.

Abdomen depressed, linear, a little narrowed on last two segments, both of which bear stiff spines at their posterolateral angles. Middle gill rudimentary, represented by a conic point surmounting a subtriangular plate hardly longer than wide. Two laterals long, tapering, sharply triquetral, margins beset with stout spines intermixed with slender hairs. Laterals brownish banded with pale in middle and at tips.

Two well-grown specimens from Molawin Creek, Los Baños, June 26, 1926, from *Dr. L. B. Uichanco.*

While not reared, these nymphs agree in number of nodal crossveins with *colorata* and not with *turconii,* the other local species.

LIBELLAGO ASIATICA Sélys.

SÉLYS, Bull. Acad. Belg. (2) 47 (1879) 384, male, female, Luzon, Mindanao; An. Soc. Esp. Hist. Nat. 11 (1882) 20, Luzon, Mindanao; ibid. 20 (1891) 216, Dolores.

Abdomen, 21 to 22 mm; hind wing, 18 to 19.

We have no specimens of this small species. It is clear-winged, with scantier venation than *Rhinocypha,* and differs further in having vein M_4 zigzagged beyond the quadrangle.

MICROMERUS LINEATUS Burmeister.

BURMEISTER, Handb. d. Ent. 2 (1839) 826; FRASER, Fauna Br. Ind. 2 (1934) 60 (full bibliography).

Hind wing, 16 to 20 mm.

This species, not as yet reported from the Philippines, is known from Formosa and Borneo, and it thus being found on either side of the Islands we have included the genus in the key. It is a slender pale species with wings stalked halfway out to the quadrangle and with only five or six antenodal crossveins. It is unique in our fauna in the skewness to rearward of the middle fork (Mf), and in the remarkable slant of the medioanal link (ma). By these characters it should be easily recognized.

Its nymph was figured by Fraser[6] and the figure was copied by the senior author in his Manual of the Dragonflies of China, plate 17, fig. 4.

DEVADATTA ARGYOIDES Sélys.

SÉLYS, Bull. Acad. Belg. (2) 7 (1859) 449, male, Singapore (in *Tetraneura*); An. Soc. Esp. Hist. Nat. 11 (1882) 20, Mindanao and Basilan; KIRBY, Syn. Cat. Neur. Odon. (1890) 111.

Male, abdomen, 31 mm; hind wing, 27.

Female abdomen, 25 mm; hind wing, 24.5.

Female hitherto unknown.

Female.—Head a rather uniform gold-brown. Labrum a little lighter with a fine line around free margin and one darker line a little behind and paralleling it. Labrum line between post- and anteclypeus, and excavate margin of occiput all with a sparse fringe of stout hairs.

Prothorax gold-brown, touched with black on tip of anterior lobe and on posterolateral margins. Synthorax of same general color, a little darker on dorsum, with three lighter stripes on the sides—one antehumeral, one on suture between segments, and one on metepisternum. Femora pale, twice ringed with darker, tibiæ and tarsi darker. Femora, tibiæ, and tarsi armed with two rows of strong spines, those on lower half of outer row on fore tibiæ very closely set and shorter than the others. Claws bifid at tip. Wings hyaline, very faintly stained with brown at extreme tip, intercalary sectors more hooked at posterior wing margin in forewing than in hind wing. Stigma evenly yellow. Ante- and postnodals 7 : 27 and 8 : 19 in forewing and hind

[6] Journ. Bom. Nat. Hist. Soc. (4) 32.

wing, respectively. First four antenodals continuous with second series in forewings, first five continuous in hind wings.

Abdomen brown, basally ringed with a fairly broad band of paler on segments 2 to 7. Sheath of ovipositor externally finely denticulate.

Male.—Head metallic steel-colored marked with livid. Thorax black, striped with livid. Abdomen marked as in female.

LUZON, Laguna Province, Los Baños, one female.

DEVADATTA FILIPINA sp. nov. Plate 13, figs. 160, 168, and 169.

Male, abdomen, 35 mm; appendages, 1.5; hind wing, 31.5.

Female, hind wing, 31.5.

Male.—Head black, with metallic green and violet iridescence, somewhat swollen behind eyes.

Prothorax dark brown, bordered behind with black. Posterior lobe entirely black, point of anterior lobe black. Synthorax black, with a pale spot directly below base of forewings, a narrow pale line on suture between meso- and metathorax; a pale spot at upper anterior corner, base and lower half of anterior margin pale, a pale stripe on middle of posterior border of metepimeron. Legs long, armed with strong spines; femora rather pale, tibiæ and tarsi darker; claws bifid at apex. Wings narrow, strongly petiolate, hyaline, margined at tips with dark brown, more broadly so in forewings than in hind wings. Stigma almost black, a trifle paler distally. Ante- and postnodals 10 : 33 and 8 : 28 in forewing and hind wing, respectively.

Abdomen black; segment 1 dark brown except for margins; segments 2 to 7 basally ringed with paler, narrower on segment 2; segment 8 showing some vestiges of this ring; superior appendages black, twice as long as segment 10; inferiors dark brown, less than a quarter the length of superiors.

Female.—Head black, metallic, paler behind vertex.

Prothorax brown, darker basally; posterior lobe black, bordered posteriorly with pale brown. Synthorax dark brown, with a pale line on each lateral suture and a pale spot in anterior dorsal corners of meso- and metepimera. Legs as in male. Wings hyaline, fuscous beyond stigma. Stigma proximally dark brown, distally creamy. Ante- and postnodals 9 : 34 and 9 : 27 in forewing and in hind wing, respectively.

Only first three segments of the abdomen present, dark brown. Segment 1 apically bordered with black, segment 2 narrowly

basally ringed with pale, segment 3 more broadly basally ringed with pale brown, with a round spot of creamy yellow in middle of each side of pale ring.

Allotype, female, Mindanao, Bukidnon Province, Tangkulan, (*C. F. Baker*).

Type, male, Mindanao, Agusan Province, Santiago, April, 1931.

This species resembles *D. multinervosa* Fraser in that the first five antenodals show correspondence between the first and second series in the forewings of the male and both wings of the female, but is widely different from it in the number of nodal crossveins. It differs from *D. argyoides* Sélys in the lack of accessory crossveins in the cubitoanal space, and from *D. podolestoides* Laidlaw in the shape of the superior anal appendages of the male. There are other minor differences.

CŒNAGRIONIDÆ

This family includes the smallest of Odonata. All our material consists of slender clear-winged species, distinguishable at a glance from all other Philippine Odonata by having but two antenodal crossveins in each wing.

The nymphs are correspondingly slender, with three thin and leaflike gills at the end of the abdomen (inflated, so far as is known, only in *Drepanosticta*). The median lobe of the labium is generally entire, never with a widely open median cleft, and both lateral and mental raptorial setæ are generally present.

Key to the genera of the Philippine Cœnagrionidæ.

ADULTS

1. Middle fork (Mf) nearer to arculus than to nodus; stigma bordered behind by more than two cells .... LESTINÆ, only *Lestes*.
   Middle fork nearer to nodus than to arculus .... 2. CŒNAGRIONINÆ.
2. Vein Cu_2 rudimentary or wanting .... 3.
   Vein Cu_2 well developed .... 5.
3. Subquadrangle divided by a vein that cuts off a small diamond-shaped basal portion .... *Drepanosticta*.
   Subquadrangle open, undivided .... 4.
4. Anal crossing (Ac) resting on hind wing margin .... *Protosticta*.
   Anal crossing separated from hind margin by an intervening cell. *Caconeura*.
5. With supplementary or intercalated sectors between some of principal longitudinal veins .... *Rhinagrion*.
   With no such sectors (other than M_1a) .... 6.
6. Tibial spines very long, twice as long as intervals between them .... 7.
   Tibial spines short, rarely longer than their intervals .... 8.

Verification Table.

Genus.	Crossveins.		Stigma.	Middle fork.	Crosslines between subnodal crossline and crossline decending from base of vein M_3.		Anal crossing	Front of quadrangle.[b]	Hind wing.
	Nodal.	Apical.[a]			Fore-wing.	Hind wing.			
									mm.
Agriocnemis	2: 5–2:7	1	Longest in front	Before subnodus	2	1	Beyond end of wing stalk	0.5	11–12
Argiocnemis	2:10	3	do	do	4		do	0.7	17–20
Amphicnemis	2:12–2:14	2	Longest in rear	Beyond subnodus	7		Before end of wing stalk	0.7	20–21
Caconeura	2:16–2:18	5–7	Regular	Before subnodus	5		Beyond end of wing stalk	1.0	22
Ceriagrion	2: 9–2:12	3–4	do	do	5	4	At end of wing stalk	0.3	22
Cœliccia	2:14–2:15	3	Longest in rear	Beyond subnodus	7	5	do	1.0	26
Cœnagrion	2: 7–2: 9	2–3	Varying	Before subnodus	3	2	Beyond end of wing stalk	0.3	16–17
Drepanosticta	2:13–2:15	6–8	Regular	do	5	4	Before end of wing stalk	1.0	20
Ischnura	2: 7–2: 9	2–4	Longest in front	do	3	2	Beyond end of wing stalk	0.3	13–17
Moroagrion	2:12–2:13	5	Longest in rear	do	4	3	do	0.4	23
Pericnemis	2:12–2:15	3–4	do	Varying	5–7		Before end of wing stalk	0.4	28–37
Prionocnemis	2:15–2:23	3–5	Regular	do	4–6		Varying	0.9	23–29
Protosticta	2:15	7–10	Longest in rear	Beyond subnodus	6	5	Before end of wing stalk	1.0	21
Pseudagrion	2: 8–2:13	4–5	Longest in front	Before subnodus	4–6		Varying	0.4	17–24
Rhinagrion	2:10–2:12	2–3	Regular	do	3	3	do	0.7	25–26
Teinobasis	2:11–2:14	2–3	Varying	Beyond subnodus	7	5	Before end of wing stalk	0.3–0.4	21–25

[a] Space beyond stigma.

[b] In tenths of length of hind side.

7. Base of vein Rs one or two cells beyond subnodus .... *Cœliccia.*
   Base of vein Rs four or five cells beyond subnodus .... *Prionocnemis.*
8. Arculus out beyond second antenodal crossvein .... 9.
   Arculus opposite second antenodal crossvein .... 11.
9. Middle fork before subnodus .... 10.
   Middle fork beyond subnodus .... *Teinobasis.*
10. Postnodal crossveins 10 to 12 .... *Argiocnemis.*
    Postnodal crossveins 6 to 8 .... *Agriocnemis.*
11. Middle fork before subnodus .... 12.
    Middle fork beyond subnodus .... 17.
12. Wing stalked not as far out as anal crossing .... 13.
    Wing stalked to or beyond anal crossing .... 16.
13. Stigma covering more than a single cell .... *Moroagrion.*
    Stigma covering not more than a single cell .... 14.
14. With 6 or 7 crosslines between subnodal and 1 crossline descending from base of vein M_2 .... *Pseudagrion.*
    With three or four such crosslines so situated .... 15.
15. Female with no midventral apical spine on abdominal segment 8; male with no middorsal bifid apical elevation on abdominal segment 10. *Cœnagrion.*
    Each sex with these characters .... *Ischnura.*
16. Head and thorax with a pattern of bright colors .... *Pseudagrion.*
    Head and thorax concolorous, without pattern .... *Ceriagrion.*
17. Wings stalked to anal crossing .... *Pericnemis.*
    Wings stalked much beyond anal crossing .... 18.
18. Subanal plates of male normal, rounded .... *Amphicnemis.*
    Subanal plates of male long, pointed, appendagelike .... *Teinobasis.*

NYMPHS[7]

1. With raptorial setæ on movable hook of lateral lobe of labium .... *Lestes.*
   With no setæ on this hook .... 2.
2. Median lobe of labium cleft at apex .... 3.
   Median lobe of labium entire at apex .... 4.
3. Cleft open; no raptorial setæ .... *Drepanosticta.*
   Cleft closed; labium with one lateral seta on each side .... *Rhinagrion.*
4. With but 1 mental seta on each side .... 5.
   With 3 or 4 mental setæ on each side .... 6.
5. Gills parallel-sided; with a joint across middle .... *Pseudagrion.*
   Gills obovate; no joint across middle .... *Ceriagrion.*
6. Lateral setæ 4 or 5 .... *Agriocnemis.*
   Lateral setæ 6 or 7 .... 7.
7. Gill tips merely acute; mental setæ 4 or 5 .... *Cœnagrion.*
   Gill tips acuminate; mental setæ 6 or 7 .... *Ischnura.*

[7] This key is to be used with due regard to the fact that nymphs of many native species and even genera are still unknown, and that the characters stated for the four genera last named in the key are drawn from species not found in the Philippines.

Genus LESTES Leach

Of the two species of this genus recorded from the Philippines, *L. præmorsa* Sélys and *L. concinna* Sélys, only the latter is represented in the material before us. Both are dully colored yellowish species that develop distinctive color patterns at maturity and become blackish with age. In general they will be readily distinguished by the following key.

Key to the species of Lestes.

1. Front of synthorax each side with a blackish stripe that is trilobed on its outer margin; sides behind humeral suture with a number of fuscous dots; dorsum of abdomen becoming uniformly darkened. *præmorsa.*

   Front of synthorax with a single wide median parallel-sided blackish band (often lacking; never with paired stripes farther out); sides wholly pale; abdomen with a middorsal blackish stripe on segments 8 to 10 .... *concinna.*

Nymphs of the genus *Lestes* are very elongate and slender. They are easily recognized by the form of the labium, which is excessively long, narrow, with converging sides in its basal half, and then suddenly expanded to its spoon-shaped end. The lateral lobe is so remarkably formed as to be quite distinctive of the genus (Plate 15, fig. 217). It terminates in a very deeply demarcated end hook above which are two spines with a serrated terminal border between them; also the movable hook is armed with 2 or 3 strong raptorial setæ. The gills are long and thin, pedunculate at base and obscurely segmented along axis beyond base. The best account of specific characters within the genus is that by Ris for European species.[8] No Philippine nymphs of this genus have come to us.

LESTES PRÆMORSA Sélys.

SÉLYS, Bull. Acad. Belg. (2) 13 (1862) 36, Manila; LAIDLAW, Ind. Mus. Rec. 16 (1919) 154, fig.; RIS, Zool. Mededeelingen 10 (1927) 11; NEEDHAM, Man. Dragonflies of China (1930) 235, pl. 16, fig. 6.

LESTES CONCINNA Sélys. Plate 15, figs. 214 and 218.

SÉLYS, Bull. Acad. Belg. (2) 13 (1862) 27, Manila; An. Soc. Esp. Hist. Nat. 11 (1882) 21; ibid. 20 (1891), Dolores.

A number of specimens of both sexes and of all degrees of maturity permits us to amplify the brief characterization of de Sélys that, for Philippine material, was based on a single teneral

[8] Festschr. f. Zschokke No. 22 (1922).

specimen. Our tenerals agree quite well with that description, except that the very variable middorsal brown line on abdominal segment 8 is rarely (and then only indistinctly) 3-lobed. The stripe of which it forms a part extending the length of segments 8, 9, and 10 is constantly present, as is also in the male a black line on the lateral margin of segment 9. The fuscous thoracic stripe that covers the middorsal carina is very variable, as is the brown line on the femora. There are, however, minute points of coloration on the two basal abdominal segments that appear to be very constant: a blackish dot on the side of segments 1 and 2, visible from the side, and a streak (two dots conjoined) in the pleural sutures of segment 1, visible only from below. There is an obscure transverse subapical mark of brown across the dorsum of segments 1 to 7, visible in most specimens. All these markings become overspread with a general infuscation in old specimens. It is only in these that the yellowish stigma becomes distinctly fuscous with pale terminal area. The dorsum may become black, but apparently never metallic.

Genera PLATYSTICTA Sélys, PROTOSTICTA Sélys, and DREPANOSTICTA Laidlaw

The material supplied us has been inadequate for determining the generic standing of some of the Philippine species that have been described under these generic names. Brauer described two species and Sélys one under the older and more inclusive name *Platysticta,* one of which, *P. halterata* Brauer, undoubtedly belongs in *Drepanosticta,* and one other, *P. annulata* Sélys, probably does not. Cowley has more recently added three new species to *Drepanosticta.* Cowley says[9] they all "should be transferred to *Drepanosticta,*" but he also says "these three species are not known to me." De Sélys says at the end of his original description of *P. annulata,* "Le rudiment du sector inférieur du triangle manquant tout á fait, comme chez la *Protosticta simplicinervis.*"

Only one of these six species is represented in the collections before us, *Drepanosticta lymetta* Cowley. We therefore will undertake nothing further than a fuller characterization of that species, still insufficiently known; the description of a new species from a female specimen; and a listing of the others with bibliographic references.

[9] Trans. Ent. Soc. Lond. 85 (1936) 166.

Leaving Sélys's *P. annulata* and our *D. septima* out of account and assuming that all the others belong in *Drepanosticta,* the males may be separated by the following key.

A key to the species of Drepanosticta.

MALES

1. No erect processes arising from hind lobe of prothorax............ *lestoides.*
   Horns or prominences of some sort present... 2.
2. These processes upcurving triangular points.................................. *myletta.*
   These processes longer and more or less dilated apically......................... 3.
3. These processes short, flat, each about as wide as interval between them. *megametta.*
   These processes much slenderer .... 4.
4. These processes obliquely truncate at converging tips.................. *lymetta.*
   These processes very long, sinuous, knobbed at end..................... *halterata.*

DREPANOSTICTA LYMETTA Cowley. Plate 15, figs. 197, 198, 200, 202, and 205; Plate 22, fig. 310.

COWLEY, Trans. Ent. Soc. Lond. 85 (1936) 661, figs., Surigao Province, Mindanao.

Abdomen, 27 mm; hind wing, 20.

Our material from the type locality agrees fairly well with Cowley's description of the type material (two incomplete males, lacking the end segments of the abdomen) and with his figure of the appendages of the thoracic dorsum. These characters are adequate for recognition.

A slender, plain, brownish, yellow-legged species, with abdomen ringed with yellow. In the alcoholic specimen before us the dorsum of the head is blackish, with the ocelli paler. Labrum and antennæ yellow. Legs yellow, including spines and claws, an obscure submedian band of brown on all femora. Thorax smoothly polished, pale brown except between leg bases beneath and at junction with abdomen. Wings hyaline, with brown veins and yellowish stigma. Abdomen lighter brown, with rather wide pale rings on base of segments 3 to 7.

The sexes are practically alike except for the hind lobe of the prothorax as shown for both sexes in Plate 15, figs. 198 and 202, and also the terminal abdominal segment.

In the male, segment 10 is half as long as segment 9, one-third as long as segment 8, and a little less than half as long as the appendages. These segments brown, only a little paler beneath and on appendages, and with hair lines of black on transverse apical carinæ. Appendages as shown in Plate 15, figs. 197 and 200.

A single female came with one of the males from Surigao Province (in the same envelope, whereas all the other males were separately papered) and is presumably but not indubitably of the same species. It is paler, with a plain ovipositor, and the dorsum of segments 7 to 10 is wholly pale. The sheath of the ovipositor is smooth, angulate on both angles at its tip, and bears a slender palp that is wholly pale (Plate 15, fig. 205).

DREPANOSTICA HALTERATA Brauer.

BRAUER, Verh. Zool. Bot. Ges. Wien. **18** (1868) 551, Luzon; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 30, Mindanao, May; Mem. Cour. **38** (1886) 153.

Male, abdomen, 36 mm; hind wing, 25.

Female, abdomen, 29 mm; hind wing, 21.

DREPANOSTICTA LESTOIDES Brauer.

BRAUER, Verh. Zool. Bot. Ges. Wien. **18** (1868) 552, Mindanao; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1881) 30, Mindanao, December 10 to 12; Mem. Cour. **38** (1886) 154.

Male, abdomen, 43 mm; hind wing, 25.

DREPANOSTICTA MYLETTA Cowley.

COWLEY, Trans. Ent. Soc. Lond. **85** (1936) 160, Borongan, Samar.

Male, abdomen, 29 mm; hind wing, 19.

DREPANOSTICTA MEGAMETTA Cowley.

COWLEY, Trans. Ent. Soc. Lond. **85** (1936) 163, Mindanao, Surigao Province.

Male, abdomen, 29 mm; hind wing, 18.

Female, abdomen, 29 mm; hind wing, 21.

PROTOSTICTA ANNULATA Sélys.

SÉLYS, Mem. Cour. **38** (1886) 156 (in *Platysticta*), Luzon.

Female, abdomen, 29 mm; hind wing, 21.

DREPANOSTICTA SEPTIMA sp. nov. Plate 15, figs. 201 and 204.

Abdomen, 31 mm; hind wing, 21.5.

Postnodal crossveins 15 and 13 in forewing and hind wing, respectively.

Female.—The color pattern of this single, rather immature specimen is remarkably similar to that of *D. lymetta*, except that there is a middorsal black stripe on abdominal segments 8 to 10, narrowly divided lengthwise by paler. The form of the hind lobe of the prothorax as viewed from the front is distinctly 3-lobed and much wider, being almost the width of

the body of that segment. The caudal appendages are much longer. The sheath of the ovipositor is very different, being strongly serrate on its lower border and rounded at both apical angles where that one is angulate. The palp at the end is stout and black-tipped.

The single female specimen with abdominal segment 6 broken in two in the middle and flattened, was collected in the island of Samar by R. C. McGregor, April 29, 1924.

DREPANOSTICTA sp. Nymph.

The nymph of *Drepanosticta* is known for one species that Lieftinck has described from Java, *D. sundana.*[10] Plate 15 shows his figures of the nymph. It is most remarkable for the entire lack of raptorial setæ on its gomphinelike labium.

CACONEURA INTEGRA Sélys. Plate 17, figs. 244 and 245; Plate 20, fig. 294.

SÉLYS, Mem. Cour. 38 (1886) 172 (in *Disparoneura*); An. Soc. Esp. Hist. Nat. 11 (1882) 30, Basilan, Mindanao.

Male, abdomen, 31 to 34 mm; hind wing, 20 to 22.

We have a single male specimen from Kabasalan, Zamboanga Province, Mindanao, taken in July, 1932, by H. C. Muzzall. It is slightly larger than the single specimen of de Sélys, but agrees well with his description of coloration. A blackish species with a bluish stripe across head from eye to eye through ocelli, with sides of synthorax broadly and regularly striped with black and blue. Postnodal crossveins about seventeen and fifteen in forewing and hind wing, respectively. But one line of crossveins between quadrangle and subnodal line; the lines farther out are at 5—5—5-line intervals between ultranodal sectors. Abdomen black, with small blue areas at both ends on several segments. Male appendages (Plate 17, figs. 244 and 245) distinctive.

CACONEURA OBSOLETA Sélys.

SÉLYS, Mem. Cour. 38 (1868) 173 (in *Disparoneura*); An. Soc. Esp. Hist. Nat. 11 (1882) 31 ("Quelle des Banko").

This species we have not seen. It is known only from a single discolored teneral specimen. Hardly anything in the de Sélys description seems to distinguish it from the preceding species except the greater length of the abdomen, and that might be due to the flaccid condition of a teneral specimen, allowing the telescoped joinings of the segments to be extended. More and better material is needed to determine the status of this species.

[10] Treubia 14 (1934) 463–8.

RHINAGRION PHILIPPINUM Sélys. Plate 15, figs. 206 to 213, 215, and 216; Plate 20, fig. 291.

SÉLYS, An. Soc. Esp. Hist. Nat. 11 (1882) 21, Bohol; Mem. Cour. 88 (1882) 94.

Male, abdomen 35 mm; appendage, 1.5; hind wing, 25.

Female, appendage, 35 mm; hind wing, 27.

Female hitherto unknown.

Female.—Head patterned with black and olivaceous cream. Labrum black; base of mandibles pale; postclypeus black; anteclypeus black, longitudinally divided in center by a pale band; antennæ black, with a pale ring around distal end on segment 1; eyes surrounded by a broad band of pale but with a long narrow cuneiform black spot against them on their occipital borders. An irregular T-shaped black spot over frons, vertex, and occiput. (Plate 16, fig. 206.)

Prothorax pale olive-cream on posterior lobe, on sides and on venter; on anterodorsal portion a hastate spot of black lying in an area of rich golden brown. Synthorax light golden brown on sides and dorsum, marked with greenish as follows: A pair of large oval spots on dorsum, an oblong spot lying vertically on top of mesepisternum and metepimeron, another spot on bottom of same sclerites and on metepisternum; dorsal half of metepisternum greenish. Venter of synthorax pale greenish. Wings hyaline, with black veins and dark-brown stigma. Femora pale, darkened at joints with tibiæ. Tibiæ somewhat darker, especially at ends. Tarsi black. Femora, tibiæ, and tarsi armed with two rows of long strong spines, outer row on fore tibiæ very closely set on distal half.

Segment 1 of abdomen greenish, segments 2 to 10 reddish brown marked with paler and black. Apical carinæ black, preceded by a pair of dorsal light spots, larger on segments 2, 7, 8, 9, and 10. On segments 8 and 9 these spots extend almost the length of the segment. In more teneral specimens there is a lateral dark longitudinal stripe on segments 3 to 10. Tip of appendages black.

Male.—Pattern on head, as far as can be seen in so teneral a specimen, generally same as in female. Wings as in Plate 20, fig. 291.

This species has been known hitherto from a single teneral male specimen, from which the last four segments of the abdomen were lacking. We are glad to be able to present a more complete description and figures of both sexes, and also of the nymph. Among the cœnagrionines the adult will be readily

recognized by the unbraced stigma covering two cells and by the presence of intercalated sectors between the principal veins of the wing: also, in the female, by the huge ovipositor with its very long palp.

LUZON, Laguna Province, Los Baños, 5 females, (*L. P. Zialcita, R. Gines, Ernesto Padilla, M. Allas,* and *C. Pañgramuyen*) ; 1 male and 1 female, collector unknown. Bangayas Bay, 1 female (*E. Carandang*).

RHINAGRION PHILIPPINUM Sélys. Nymph.

Length, 15 mm; gills, 4 additional; abdomen, 8.

Width, head, 5 mm; abdomen, 4.

A rather stout, smooth, brownish nymph with depressed head with sagging hind angles behind the rounded eyes, and with short, broad, heavily pigmented gills. Head flattened above, widest across the large eyes, then parallel-sided to the rounded and scurfy-spinulose hind angles, between these angles a widely excavate occipital border. Antennæ about as long as head, pale beyond the two basal segments. Relative length of the seven segments 5 : 10 : 12 : 13 : 10 : 7 : 5. At side margin of squarish head and beneath eye a longitudinal carina armed with about a half dozen sharp teeth that are visible from above. Just behind these teeth a series of more minute teeth that crown the outer hump on the mandible. Labium short, broad, and flat, its length to tip of median lobe hardly greater than its breadth, its basal width half its apical, its sides almost straight-margined. Median lobe prominent, with a closed middle cleft, its border retrorsely and irregularly denticulate. Mental setæ lacking. Lateral lobes narrow, each armed with a single raptorial seta beside base of which is a minute spinule. End hook very short; next to it on terminal border a stout hook almost as long as movable hook, between these two hooks another bladelike hook half as long, with both edges microscopically serrulate. Mandible armed with a terminal vertical row of stout arcuate teeth that diminish in size downward; on inner, concave side, two or three short clawlike unequal smaller teeth. Low, rounded outer bump of mandible covered with pedicellate spinules, serrately arranged, with tips pointing forward.

Disc of prothorax shield-shaped, rounded behind, with projecting truncate articulation prominence in front. Beneath low flaring front angles of prothorax two longitudinal carinæ, both carinæ armed with denticles that point forward, lower

carina on coxa. Wings on this nymph (probably penultimate instar nymph) reach backward to middle of abdominal segment 6. Legs brownish on femora and tibiæ, twice banded with paler. Outer carinæ of femora minutely serrulate. Tarsi pale.

Abdomen stout, little depressed, regularly tapering to rearward, with a pale middorsal longitudinal line bordered by a single pair of sooty spots on each segment. Gills short, broad, oblong, very black except at extreme apex; laterals with midlateral carinæ for half their length, carinæ spinulose-serrate externally. Lateral margins of last two abdominal segments similarly margined.

The developing venation in the wings shows the intercalated sectors that characterized only this known species in the fauna.

LUZON, Laguna Province, Mount Maquiling, altitude 200 feet, April 9, 1932, five nymphs, only one well grown and with gills preserved.

A nymph, apparently of this genus, was described and figured by the senior author in 1911 as belonging to the Sélysian "Legion Podagrion." [11] At that time it was not more closely determinable. The specimen was loaned to me for study by the Museum of Comparative Zoölogy, Cambridge, Massachusetts. It bore the museum number *334*, and was labelled as coming from India, without more specific locality designation. A comparison of the figures above cited with those of *R. philippinum* presented shows close agreement herewith. A further comparison of the venational characters cited in the above-mentioned paper with those shown by Fraser for adult *R. mima* from Burma [12] shows only very minor differences. The most notable recorded difference is in the much smaller number of apical costal crossveins beyond the stigma in *R. mima:* about four in *mima,* about ten in the unknown nymph. The latter may well represent a species that is still unknown in the adult stage.

CŒLICCIA DINOCERAS Laidlaw. Plate 17, figs. 249 to 251.

LAIDLAW, Philip. Journ. Sci. 28 (1925) 562, male, figs., Kolambugan, Lanao Province, Mindanao; Rec. Ind. Mus. 34 (1932) 33.

Male, abdomen 36 mm; hind wing, 25.

We have a single male from Mount Cantugas, Surigao Province, Mindanao, that agrees well with Laidlaw's description, but not quite so well with his figure of the prothoracic horns which

[11] Entom. News 22 (1911) 342, 343, pl. 11, figs. 1–4.

[12] Faun. Brit. Ind. 1 (1933) 92, fig. 41.

may be variable; so we show a figure of them as they appear from the front in our specimen. In a side view (such as Laidlaw's fig. 3) they show the terminal lobings of the upper side that suggest budding branches. These horns instantly distinguish it from the following species. Postnodal crossveins sixteen and fifteen in forewings and hind wings, respectively. Middle fork, Mf, at subnodus, with Rs arising well beyond it. Dorsum of the thorax with a pale stripe on each side, arising from front and tapering upward to a point, with an isolated more lateral spot near the crest.

CŒLICCIA BRACHYSTICTA Ris.

RIS, Suppl. Ent. 1 (1912) 63, male and female, Naujan, Mindoro.

Male, abdomen, 44 mm; hind wing, 30.

Female, abdomen, 41 mm; hind wing, 30.

This species we have not seen. It differs most strikingly from the preceding in lacking the great horns of the hind lobe of the prothorax, the prothorax being broadly and evenly rounded. Postnodal crossveins nineteen and seventeen in forewing and hind wing, respectively. Middle fork, Mf, just before subnodus, Rs arising beyond it. Dorsum of thorax wholly black.

This species was overlooked by Laidlaw in 1925, but was listed in his monograph of *Cœliccia* in 1932.

Genus PRIONOCNEMIS Sélys

This genus is peculiar to the Philippines and is one of the most interesting in the fauna. Five of the known species were described by Brauer in 1868 and three by de Sélys later. Only one of these, *P. hæmatopus*, has been adequately illustrated, and the nymph has not hitherto been described for any of them. We have had before us seven of the eight species and nymphs of one. For one species, *P. serrata*, we have had abundant material in all degrees of maturity, from callow tenerals to obfuscated seniles, and it has been very instructive as to the vast color changes that some species of the genus undergo.

The genus is readily recognized by easily observable characters of wing venation. The middle fork, Mf, is far out in the wing, at or even a little beyond subnodus. Veins Rs arising from four to eight cells farther out, unusually close to base of vein M_2. Apical margin of wing more or less sinuate, by reason of emargination between vein tips. Correlated with the extent of this crenulation of the wing margin is the position of the arculus in relation to the second antenodal crossvein. When

the crenulations are rather deep and extensive, as in *serrata, erythrura,* and *appendiculata,* the arculus is situated well beyond that crossvein; when shallow and few, as in *atropurpurea* and *hæmatopus,* the arculus is opposite it.

Sélys also described another species, *flammea,* from Mindanao, which we have not seen but are inclined to regard merely as a form of *ignea* and have omitted from the key below.

De Sélys (1882) offered a tentative key to the species, based mainly on color characters, which serve fairly well with fully colored male specimens. We give below a modification of that key, like his (except in the first rubric), applicable only to fully colored males. The color pattern of females and all tenerals is given in Plate 14, figs. 171 and 172.

Key to the species of Prionocnemis.

ADULT MALES

1. Body black, spotted and streaked with blue .... 2.
   Body black or red or both without blue spots .... 3.
2. Middle lobe of prothoracic dorsum with a pair of low rounded tubercles .... *serrata.*
   Middle lobe with a pair of erect yellow horns (female) .... *cornuta.*
3. Postclypeus metallic blue, body shiny black, tinged with purplish; legs chalky white internally .... *atropurpurea.*
   No metallic blue on face and no white on legs .... 4.
4. Body black and red .... 5.
   Body wholly red .... 6.
5. Legs black .... *erythrura.*
   Legs scarlet .... *hæmatopus.*
6. Postclypeus blackish .... 7.
   Postclypeus reddish .... *ignea.*
7. Legs wholly reddish .... *rubripes.*
   Legs brownish, with blackish marks on knees and at base of claws. *appendiculata.*

PRIONOCNEMIS SERRATA Sélys. Plate 14, figs. 171 to 173, 184 to 186, and 191 to 195.

SÉLYS, Bull. Acad. Belg. (2) 16 (1863) 154, Manila; An. Soc. Esp. Hist. Nat. 11 (1882) 24, Mindanao; ibid. 20 (1891) 216, Dolores.

A hyaline-winged jet-black species very prettily marked with deep blue, and with outer ends of wing margins conspicuously serrate; but the coloration is extremely variable. In fully colored males the lower half of the face is blue, also the entire prothoracic dorsum except for a median black line that is widened at the rear. Two broad oblique blue bands on sides of synthorax, anterior band of double width in lower half. Abdominal segments with subapical blue rings, widest and

brightest blue on segment 2. None of these markings developed on teneral specimens, all less distinct on females. Also, they are very erratic in their variability, some being developed when others are not. Rings on abdomen white, or some white and others blue. Segments 10 of abdomen and appendages wholly white or wholly black or anything intermediate, appendages when white often tinged with pale sky-blue. Pale legs darkened at knees and may become distinctly lineate with fuscous on forelegs externally.

Females always show less of the blue color. The hindmost of the two bands on the sides of the synthorax rarely appears at all; the black of the thorax is purplish, the sides of the abdomen are a purplish brown, sometimes with a reddish cast, and the subapical rings on the abdominal segments are white.

Teneral specimens of both sexes are wholly pale, with darker joints to all the segments of both body and legs. Their wings often show a wonderfully fine iridescent color in which blue predominates. Tenerals will, however, be recognized by the form of the abdominal appendages in the male and by that of the prothoracic dorsum in the female; these are shown in Plate 14. The arculus in this species is located well beyond the second antenodal crossvein.

LUZON, Laguna Province, Mount Maquiling, Los Baños, and Ube, many specimens of both sexes; Bay, Bangyas; Batangas Province, Tanauan, Taal: Tayabas Province, Quezon Park: Cavite Province, Indang: Rizal Province, Novaliches. Practically all collectors.

PRIONOCNEMIS sp. Nymph (SERRATA supposition).

Nymph apparently in penultimate instar.

Length, 10.5 mm; gills, 3 additional; abdomen, 6.

Width, head, 3.5 mm; abdomen, 2.5.

A smooth brownish nymph with depressed head, short stout body, and wide blackish gills. Head widest across posterior third of very large and prominent eyes, narrowed at once behind them to rather small well-rounded scurfy pubescent hind angles between which it is widely and deeply excavate on the occipital border. Antennæ pale, relative length of segments variable as shown by two examples, 9 : 10 : 12 : 11 : 8 : 4 : 2 and 7 : 10 : 9 : 11 : 8 : 5 : 4. Labium broad and flat, mentum about as wide as long, an equilateral triangle with eroded angles, straight lateral margins spinulose on distal half. Median lobe very

prominent, broadly rounded at end, its margin beset with microscopic retrorse serrulations. A pair of short mental setæ starting almost in line with outermost angle and about as far from them as they are from each other. A transverse suture with a single nodule on it on each side, running across rounded tip submarginally.

Lateral lobe short, very narrow, armed with two strong raptorial setæ. Movable hook very long and strong, longer than distance to basal articulation, strongly curved, smoothly tapering. End hook unusually large, similarly curving, insensibly passing basad into retrorsely serrulate inner margin of body of lobe. On inner side of end hook a shorter bladelike piece that is minutely serrate on outer upper side and around end, but smooth on margin next to end hook.

Beside the labium and behind the basal articulation of the mandible there is a toothed carina similar to that in *Rhinagrion*.

Prothorax depressed and smooth above. Legs concolorous, like the body. Their anterior carinæ bearing minute spines, the posterior ones, sparse soft hairs. Wing cases reaching backward almost to abdominal segment 6.

Abdomen smooth, a little depressed at base, becoming cylindric at rear end, where lateral margins of terminal segments are finely serrate. Gills short, broad, dark colored, divided by a very oblique groove into a large firm brown basal portion of two thirds their entire area, and a thinner apical portion that is abruptly rounded to a blunt apex. This outer portion heavily suffused with a dark pigment except for a narrow and very hyaline terminal border. The strong lateral carinæ of basal portion heavily spinulose-serrate.

The generic determination of this nymph is positive because of the fairly well preserved venation in the wings of our specimen. The species is probably *P. serrata,* for the arculus is distinctly beyond the second antenodal crossvein, the postnodals are twenty, and the lines of crossveins farther out are well within the range of that species. The crenulations of the wing margin are not apparent, but probably do not appear at that stage of development.

This nymph is superficially similar to that of *Rhinagrion.* It is adapted to the same kind of habitat as shown by its stout smooth depressed head, and narrow lateral labial lobes. It bears a sign of real affinity in the serrated blade that stands between the movable hook and end hook at the tip of the lateral lobe, but there *Rhinagrion* has a second hook beside it.

The specimens came in two vials (in one intermixed with nymphs of *Rhinagrion*), both from Molawin Creek; one labeled "Los Baños, February, 1930, Entom. I Students" sent by Doctor Uichanco, and the other "Mount Maquiling 9 XI 1932 200' alt."

PRIONOCNEMIS CORNUTA Brauer.

BRAUER, Verh. zool.-bot. Ges. Wien **18** (1868) 548, female, Luzon and Mindanao; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 24; ibid. **20** (1891) 216, male, Dolores.

This species we have not seen. As indicated above, Brauer had only the female, and when de Sélys later obtained specimens from Dolores he apparently had only the teneral male. He concluded his description of it with the remark that the diagnostic character for the species still remains in the form of the middle lobe of the prothorax. We have therefore used this character in our key.

PRIONOCNEMIS ATROPURPUREA Brauer. Plate 14, figs. 180, 187, 188, and 196.

BRAUER, Verh. zool.-bot. Ges. Wien **18** (1868) 549, Manila; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 24 (May to July).

An elegant purplish-black species with conspicuously white femora and with only a suggestion of serrulation at the wing tips. The labrum and postclypeus are bare, shiny metallic green. The former has a thin marginal fringe of stiff brown hairs. Anteclypeus and corners of mouth white. Top of head velvety black. Entire body shiny plumbeous black with thin membranes at wing bases and at other sutures white. The male terminal appendages vary from black to white, usually being black above and white on the under side.

Female.—The female is hitherto undescribed.

Abdomen, 37 mm; hind wing, 25.

The female is so different in aspect from the male that we would have hesitated to put the two together but for McGregor's thoughtfulness in placing a pair in an envelope and marking it to indicate that they were taken in copulation. The two have but one color character in common and that is the shiny green metallic postclypeus.

Almost concolorous yellowish brown throughout, possibly reddish in life, paler beneath, with only a shiny green metallic postclypeus for distinction. Legs a little darker at joints of segments and on tarsi. Wing membrane a little tinged with brownish distally. Abdomen diffusely darkened on dorsum of middle segments and again on sides of segments 8 and 9. The

diagnostic character is again found in the conformation of the prothoracic dorsum, shown in Plate 14, fig. 180.

LUZON, Laguna Province, Los Baños, April 23, 1931, 2 males (*F. Juan*), April 25, 1931, 1 male (*McGregor and Celestino*); Ube, March 2, 1 male (*McGregor*), April 25, 1 female (*McGregor*), April 19, 1 male and 1 female (*McGregor*).

PRIONOCNEMIS ERYTHRURA Brauer. Plate 14, figs. 178 and 179.

BRAUER, Verh. zool.-bot. Ges. Wien **18** (1868) 550, Philippines; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 24 (May 24 and 25).

Abdomen, 35 to 40 mm; hind wing, 24 to 26. The smaller of these measurements are from our single specimen, a mature male.

A sooty blackish species, with blackish legs, and slender abdomen that is moderately enlarged to rearward on segments 7 to 10, and reddish on these segments. Wings slightly tinged with brown, strongly crenulate around outer end. The form of the male appendages is shown in Plate 14, figs. 178 and 179.

Female unknown.

We have seen but a single male specimen, taken at Quezon Park, Tayabas Province, May 13, 1931 (*F. Juan*).

PRIONOCNEMIS HÆMATOPUS Sélys. Plate 14, figs. 177, 189, and 190.

SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 25, 1 pl., Mindanao.

Male, abdomen, 39 to 41 mm; hind wing, 23 to 25.

Female, abdomen, 33 to 37 mm; hind wing, 25 to 26.

This species was illustrated by de Sélys in an excellent color plate. It is a large and very striking species by reason of its black mantle covering head and front of thorax, its orange sides, and its scarlet legs and feet. The female is mainly orange and paler, and also has scarlet legs.

Our specimen agrees closely with the type.

LUZON, Tayabas Province, Quezon Park, 3 males, collector unknown, 1 male and 1 female, May 10, 1931 (*F. Juan*), 1 female, May 29, 1931 (*F. Juan*): Laguna Province, 1 male, December 26, 1930, collector unknown; Los Baños, 2 males, March 25, 1930 (*G. I. Perez*), 1 male, January 30, 1931 (*L. Boongaling*), 1 male, April 21, 1931 (*F. Juan*), 1 male, December 20, 1931 (*L. Boongaling*), 1 male, February 10, 1932 (*J. Amores*); College campus, 1 male and 1 female, February, 1931 (*M. E. Rosell*), 1 female, February 10, 1932 (*J. Reyes*); Mount Maquiling, 1 male and 1 female, January 28, 1930 (*A. C. Duyag*), 1 female, January 27 to 31, 1930 (*A. C. Duyag*): Cavite Province, 1 male, December, 1930 (*M. E. Rosell*).

PRIONOCNEMIS IGNEA Brauer. Plate 14, fig. 174.

BRAUER, Verh. zool.-bot. Ges. Wien **18** (1868) 547, Luzon; SÉLYS, An. Soc. Esp. Hist. Nat. **11** (1882) 26, Manila.

Male, abdomen, 37 to 44 mm; hind wing, 22 to 27.

Female, abdomen, 36 to 41 mm; hind wing, 25 to 28.

A single female specimen that agrees with Brauer's rather brief description of the female type is so like the female of the preceding species that it may only be positively differentiated by the form of the hindmost lobe of the prothorax and by the ovipositor sheath which projects beyond the tips of the cerci farther than the latter are long and which in *P. hæmatopus* is only about half the length of the cerci. The hindmost lobe of the prothorax is not at all curved forward as in the preceding species but slopes a little backward and is deeply divided by a sharp median cleft. As in *P. hæmatopus,* the arculus is at the second antenodal crossvein and the wing apex is very slightly crenulate.

Our specimen bears the label: "Agricultural College, Laguna."

PRIONOCNEMIS RUBRIPES sp. nov. Plate 14, figs. 175, 176, and 183.

Male, abdomen, 41 mm; hind wing, 27.

Female, abdomen, 40 mm; hind wing, 27.

Male (*type*).—Head reddish, darker on postclypeus (sometimes with bluish reflections in darkest part) and around individual ocelli.

Prothorax and synthorax dull light orange, paler beneath, with touches of black at wing bases, middorsal carina narrowly black. Wings subhyaline, with dark-brown veins, and stigma narrow, hardly expanded in middle. Postnodals 19 in forewing, 16 or 17 in hind wing. Legs entirely brilliant scarlet, long, with long spines also scarlet. Tarsal claws bifid near tip.

Abdomen of same general color as thorax, with no very definite pattern but darker dorsally on segments 3 to 6 and on anterior end of segment 7. Appendages as shown in Plate 14, figs. 175, 176.

Female (*allotype*).—Coloration practically same as in male, with the following differences: Less dark around ocelli, prothorax narrowly bordered dorsally both anteriorly and posteriorly with dark brown, legs about same color as thorax. Wings somewhat broader than in male. Stigma yellow, bordered with dark-brown veins. Postnodals 18 in both fore- and hind wings.

Ovipositor sheath broad, parallel-sided, strongly serrate below, projecting beyond tips of cerci by about length of latter.

The most striking difference between this and other species in the genus is the form of the posterior lobe of the prothorax (Plate 14, fig. 183).

MINDANAO, Surigao Province, Dinagat, 1 male and 1 female, April 1, 1931 (*A. C. Duyag*).

PRIONOCNEMIS APPENDICULATA Brauer. Plate 14, figs. 181 and 182.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 548, Mindanao; SÉLYS, An. Soc. Esp. Hist. Nat. 11 (1882) 27 (early July to late August).

Male, abdomen, 31.5 mm; hind wing, 21.

Smaller species red all over except for a shiny blackish postclypeus. Thoracic dorsum and last segment of abdomen somewhat darkened; in some specimens this segment quite brownish. Wings a little tinged with amber, more frequently the hind wings. Wing tips rather strongly crenulate, arculus well beyond second antenodal.

Female unknown.

We have specimens (males only) from the following localities:

MINDANAO, Agusan Province, Santiago, April, 1931, collector unknown: Lanao Province, Kolambugan, May, 1932, collector unknown: Surigao Province, Mainit, June 31, 1931 (*A. C. Duyag*); Dinagat, June 12, 1931 (*A. C. Duyag*): Davao Province, Mati, April, 1927, collector unknown.

ARGIOCNEMIS RUBEOLA Sélys. Plate 16, figs. 219 and 220; Plate 20, fig. 295.

SÉLYS, An. Soc. Esp. Hist. Nat. 11 (1882) 29, Luzon; ibid. 20 (1891) 218, Sibul.

Following de Sélys we use this name, but with some doubt as to its validity. That question we must leave to others who have access to types and to material of a wider range. The one Philippine species that we have before us is represented by abundant material showing a wide range of color variation. We have no doubt it is the species listed by de Sélys, for there are red specimens that quite agree with his description.

The color characters mainly used in past descriptions are very variable, and figures of genitalia are almost wholly lacking. Fraser [13] lists *A. rubeola* as a synonym of *A. rubescens* Sélys and then says at the end of his description of the latter "The species is distinguished at a glance from *A. rubeola* by the total absence of black on the labrum", which statement is a bit confusing. Assuming the correctness of his figure of the male

[13] Faun. Brit. India 1 (1933) 406.

genitalia of *A. rubescens,* ours is certainly different, as Plate 16, figs. 219 and 220 will show.

Such is the aspect of maturity in many of our red specimens that we are not wholly convinced that they are merely younger specimens. We prefer to treat the blacks and reds of this bicolorous species as two color phases, at least until they have been reared through their reproductive cycle.

Black and blue phase.—Adult male predominantly black with bright blue stripings on synthorax. Top of head black, with large oval blue postocular spots close to eyes. These spots a little longer than wide and lying with their long axes lengthwise to body. Face blue, paler near eyes, with more or less black upon postclypeus and on lateral margins of labrum. Antennæ black.

Prothorax black above, with blue anterior lobe, light touches of blue at sides of posterior lobe, a blue streak running down on front to fore femur. Synthorax black in front, with an antehumeral stripe of blue, continuous from crest to collar. Sides blue with a black stripe that extends from hind wing base to trochanter of hind leg, curving downward at its lower end.

Legs black on femora externally, on tibiæ internally, and on tips of tarsi, with black spines and claws. Femora a pretty blue at base. Wings subhyaline, with brown veins and stigma. Postnodal crossveins ten or eleven and nine or ten in forewing and hind wing, respectively. Wings not stalked as far out as anal crossing.

Abdomen black above on segments 1 to 7 and on segment 10; segments 8 and 9 blue. Sides of segments 1 and 2 blue with diminishing lateral streaks of same color on segments 3, 4, and 5; segment 10 pale only underneath. Superior appendages stout, fuscous, forcipate, obliquely truncate at end and with a very large inferior basal tooth. Inferiors paler, bidentate at end, outer tooth longer.

Red phase.—Male (apparently fully adult). Similar but wholly lacking blue color, except on postocular spots, and almost lacking black on abdomen. Abdomen reddish, brightest on dorsum of middle segments. Sides of thorax and legs pale, leg spines and tips of tarsi black. Abdominal segments 8 and 9 pale, segment 10 wholly brownish.

The male appendages are identical in both phases, and the females are similar to their corresponding males, but less brightly colored.

LUZON, Laguna Province, Pila, Los Baños; Ube; Bay, Bangyas: Manila: Nueva Vizcaya Province: Bulacan Province, Ipo: Rizal Province, Novaliches; Makabud, San Francisco del Monte: Tayabas Province, Lucban. MINDANAO, Zamboanga Province, Kabasalan. Many specimens.

AGRIOCNEMIS FEMINA Brauer. Plate 18, figs. 265 and 266; Plate 21, fig. 302.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 554 (in *Agrion*), Luzon; SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 149 (as *A. cricisa*); An. Soc. Esp. Hist. Nat. 11 (1882) 29 (as *A. cricisa*), Basilan; NEEDHAM, Zool. Sinica Ser. A 11 (1930) 254 (pl. 9, fig. 3, male, appendage), Formosa; FRASER, Faun. Brit. Ind. Odon. 1 (1933) 402 (figs., male appendages).

Abdomen, 16 to 17 mm; hind wing, 11.

This diminutive damselfly, one of the smallest in the order Odonata, is both widespread and abundant in the Philippines. It exhibits an extraordinary variety of coloration, varying with age, sex, and phase, but it is generally blackish above, greenish or reddish on its sides, and yellowish beneath. Old males become very pruinose on the face, thorax, and femora, taking on the appearance of having been heavily dusted with flour. Males will be readily distinguished from the following species by having the stigma of the same color in forewing and hind wing, and by the form of the caudal appendages.

AGRIOCNEMIS VELARIS Sélys. Plate 18, figs. 267 and 268.

SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 146 (as *A. pygmæa*), Manila; An. Soc. Esp. Hist. Nat. 11 (1882) 29.

Abdomen, 20 mm; hind wing, 11.

Of this species we have received but few specimens. None of the males are pruinose. The stigma of the forewings is much paler than that of the hind wings. The sides of the body and the small oval postocular spots on the head are bright green. The appendages of the abdomen (Plate 18, figs. 267 and 268) are strikingly different from those of the preceding species.

LUZON, Tayabas Province, Candelaria, 2 males and 1 female, April 22, 1930 (*F. Rivera*).

ARGRIOCNEMIS LUNULATA Sélys.

SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 139, Malaysia, Celebes, Sulu; An. Soc. Esp. Hist. Nat. 11 (1882) 29, Luzon (as *A. rubeola*); ibid. 20 (1891), 218, Sibul.

Male, abdomen, 28 mm; hind wing, 17.

Female, abdomen, 26 mm; hind wing, 18.

Top of head black with round greenish postocular spots, postclypeus and labrum beyond its black base, bright green. Thorax

black in front, striped on sides with greenish. Abdomen black above, segments 7 to 10 reddish. Superior appendages of the male a little longer than 10, inferiors half as long. Postnodal crossveins eleven or twelve.

We have not seen this species; the present notes are abstracted from de Sélys' original description.

The nymph of another Oriental species, *A. lacteola,* was described by the senior author.[14]

Genus MOROAGRION novum

Body stout. Head broad, eyes set well forward. Antennal segment 1 very short, segment 2 long, equal in length to segment 3. Legs heavily built, with strong spines of length about equal to intervals between them. Tarsal claws with an inner denticle near tip. Wings not stalked as far as anal crossing, ac, rather broad in proportion to length; quadrangle rhomboidal, front margin less than half length of hind margin in forewing; arculus at second antenodal crossvein, anal crossing, ac, about halfway between first and second; Rs arising at subnodus, M_3 arising well proximal to it, both veins approximated at first intervening crossvein; stigma lozenge-shaped, covering one and one-half cells. Anal appendages of the male with processes of subanal plates enormously developed, appearing like a third pair of appendages.

In venation this genus differs little from *Calicnemis.* The upper side of the quadrangle is shorter and the space between it and the subnodal line of crossveins is longer, with three intervening crosslines in two of the four wings in the type specimen (in *C. atkinsoni* there is often but one crossline in this space in the hind wing). The stigma is a little longer and the base of vein M_2 a little farther out.

Greater differences occur in the abdomen, which is much stouter in *Moroagrion* and distinctly widened to the apex on the three last segments. Also segment 3 is relatively shorter in *Moroagrion;* it is more than twice the length of segment 2 in *Calicnemis.* The raised and denticulate ridge around a depressed field at the end of the dorsum of segment 10 is entirely lacking in *Calicnemis.*

MOROAGRION DANIELLI sp. nov. Plate 17, figs. 240 and 241; Plate 20, figs. 296 and 297.

Male, length, 39.5 mm; abdomen, 29; appendage, 1; hind wing, 22.

[14] Dragonflies of China (1930) 255, pl. 19, fig. 2.

A brilliant black and orange species. Head gross, covered with stiff hairs, black, with yellow and orange markings: a band across front of labrum, one band covering anteclypeus, one band across anterior margin of frons. Genæ and labium yellow, a pair of yellow spots on inner angles of occipital border. First two segments of antennæ with apical rings of yellow.

Prothorax black, with an orange margin on front and hind lobes and a large orange spot on sides on posteroventral corner. Synthorax black, banded with orange and yellow; an orange humeral stripe broken near wing base, a yellow stripe on middle of metepimeron which does not reach to wing base, and a yellow dash on carina below wing; metepisternum mostly yellow, bordered with black, black invading yellow in upper third of metepisternum for about half its width. Legs black, shaded with orange on tarsi and terminal two-thirds of tibia.

Wings rather broad, hyaline, with dark veins and stigma. Postnodals thirteen or fourteen and twelve or thirteen in forewings and hind wing, respectively. Postnodal crosslines before the base of M_2, four and three in forewing and hind wing, respectively.

Abdomen mostly orange, sternites black. Segment 1 black, with two yellow spots on sides; segment 2 with ventral proximolateral touches of black, apical ring incomplete on dorsum; segments 2 to 6 orange with apical rings of black; segment 7 black on dorsum and halfway down sides, except for ends which, with the area below middle of sides, are orange; segment 8 dorsally black for proximal two-thirds, black emarginate distally; segment 9 similarly black for a little more than proximal half; segment 10 orange, with two dorsolateral spots of dark brown near base. Relative lengths of segments 3 : 6 : 10 : 10 : 10 : 10 : 9 : 5 : 4 : 3. On dorsum of segment 10 a terminal triangular depressed area, bordered proximally by a row of erect, stubby denticles. Anal appendages about as long as segment 10; superiors and processes of subanal plates about equal in length, inferiors somewhat shorter and turned up at tips. Superior appendages dark brown, inferiors black, processes of subanal plates yellow with black tips. (Plate 17, figs. 240 and 241.)

One male from Guara, P. I. 10 VII '03.

CERIAGRION COROMANDELIANUM Fabricius. Plate 17, figs. 247 and 248.

FABRICIUS, Ent. Syst. Suppl. (1798) 287, India; SÉLYS, Bull. Acad. Belg. (2) 42 (1876) 528; An. Soc. Esp. Hist. Nat. 11 (1881) 28, Panaon; MARTIN, Mission Pavie (1904) 18 (of reprint), Indo-China, Celebes; RIS, Abhl. Senckenb. Naturf. Ges. 34 (1908) 519; NEEDHAM, Zool. Sinica Ser. A 11 (1930) 263, pl. 19, fig. 10; FRASER, Faun. Brit. Ind. Odon. 1 (1933) 315, fig.

This widely ranging coastwise species is the most uniformly colored damselfly in the Islands; dull yellowish brown all over, only darker above and paler below as usual, and sometimes tinged with reddish, even in old dried specimens; of a more vivid tint in life.

Abdomen 28 to 30 mm; hind wing, 18 to 20.

The nymph of a related species, *C. erubescens,* was described and figured by the senior author in 1930.[15]

Genus PSEUDAGRION Sélys

Four species of this genus have hitherto been reported from the Islands. One of these we have not seen. Three additional species, apparently new to science, have come to light. Mature males of the seven species may be separated by the following key.

Key to the species of Pseudagrion.

ADULT MALES

1. Wings not stalked to anal crossing .... *pilidorsum.*
   Wings stalked to anal crossing .... 2.
2. Hind wing more than 25 mm long .... 3.
   Hind wing less than 25 mm long .... 4.
3. Sides of thorax and of abdominal segments 9 and 10 reddish.... *crocops.*
   Sides of thorax and of abdominal segments 9 and 10 blue .... *azureum.*
4. Abdominal segment 10 all black above .... *microcephalum.*
   Abdominal segment 10 partly blue above .... 5.
5. Three narrow, closely parallel stripes on front of synthorax.... *flavifrons.*
   A single broad black stripe on front of synthorax .... *evanidum.*

PSEUDAGRION PILIDORSUM Brauer. Plate 16, figs. 221 and 222.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 553 (in *Agrion*), Manila, Mindanao; SÉLYS, Bull. Acad. Belg. (2) 42 (1876) 514; An. Soc. Esp. Hist. Nat. 11 (1881) 28; ibid. 20 (1891) 218, Sibul; RIS, Nova Guinea 13 (1915) 99, fig., male, appendage, Negros; Suppl. Ent. 5 (1916) 43 (descriptive notes), Formosa.

[15] Loc. cit. pl. 18, figs. 4, 4*a*, and 4*b*.

This handsome reddish-brown species is easily recognized by the hairiness of its back—a feature indicated in its appropriate specific name. Face, femora, and basal abdominal segments rich reddish fulvous, brighter and more extensive in male. Narrowly lined with black are middorsal carina, crest, alar carinæ, and margins of postocular areas on head.

LUZON, Laguna Province, Calamba; Los Baños; Mount Maquiling; Bay, Bangyas; Calauan; Pila: Nueva Vizcaya Province; Bayombong: Cavite Province, Indang; Alfonso: Pangasinan Province, Sison: Tayabas Province, Lucban: Rizal Province, Makabud; Novaliches: La Union Province, Naguilian: Batangas Province, Tanawan, Talisay: Bulacan Province, Malolos: Isabela Province, Naguilian. Mindanao, Cotabato Province, Kidapawan: Zamboanga Province, Kabasalan. Samar. Many specimens from most collectors.

The nymph of *Pseudagrion* has been described and figured a number of times; first by the senior author in 1911,[16] then by Laidlaw in 1915,[17] by Fraser in 1919,[18] and last by Barnard in 1937.[19] Among the known nymphs of cœnagrionines, all of which run to a generally similar form of body, it will be readily recognized by its gills. The gills are long and parallel-sided, divided across the middle into inner and outer halves by a slightly oblique groove. The inner half is coarsely spinulose-serrate along both margins and along the carinate midrib; the outer half is very finely (microscopically) serrate along the edges and a little widened toward the broadly obtuse tip.

The Philippine nymphs before us come from Los Baños, Laguna Province, and they probably belong to the commonest and largest species there, *P. pilidorsum;* for they are large (16 mm + gills, 6 mm) and they show in the venation of the developing wings six crosslines between the subnodal and the base of vein M_2 in the forewing and five in the hind wing; thirteen and eleven postnodal crossveins in the forewing and hind wing, respectively.

These nymphs have but three raptorial setæ on the lateral lobe of the labium, a character that seems to vary, since others referred to this genus have four and five. All have a single mental seta on each side. The gills of this species show den-

[16] Entom. News 22 (1911) 344, pl. 11, figs. 5–8.
[17] Mem. Ind. Mus. 5 (1915) 179.
[18] Rec. Ind. Mus. 16 (1919) 467, pl. 36, fig. 2.
[19] Ann. S. Afr. Mus. 32 (1937) 214, fig. 14, *q. r. s.*

dritic clusters of tracheal branches ranged along the wide transparent marginal areas of the gill lamellæ.

PSEUDAGRION AZUREUM sp. nov.

Abdomen, 39 mm; hind wing, 27.

A handsome blue species, lightly lined on thorax and legs with black, and with dorsum of abdomen mostly black. Face blue up to ocelli, with faint markings of fuscous as follows: three triangular streaks on labrum, one median and two on lateral margins; some faint fuscous dots on anteclypeus; maxillæ and mandibles black except on outer side. A wide band of black extends across the vertex from eye to eye, with a pair of roundish pale spots in it behind lateral ocelli. Occiput blue before and behind. A pair of large quadrate black spots on pale rear of head behind eyes, narrowly connected with black line around upper edge of occipital foramen.

Prothorax blue above, with a narrow continuous blackish marginal line that is straight across the rear border of its middle lobe and sinuous at sides; also a more faint middorsal Y-mark farther forward. Synthorax intense blue in front, carina narrowly bordered with black, as are also the mesothoracic laminæ; from upper angles of latter a pair of rows of dots of faint brownish hue extending upward parallel to carina, growing fainter upward; a single pair of larger isolated dots occupies the prominences of the mesepimeron. Sides blue, with a hair line of fuscous on the humeral suture, expanded into a squarish conspicuous blotch of black on its anterior side near its upper end. A streak of black on upper end of a last suture.

Legs blue, black lines toward knees on outer margins of both femora and tibiæ; tips of all tarsal segments black; spines all black except those of foretarsal comb. Wings hyaline with black veins and stigma. Postnodal crossveins 14 and 12 in fore- and hind wing, respectively. Vein M_2 arising at postnodal seven in forewing and at postnodal six in hind wing.

Abdomen blue, black on dorsum of segments 3 to 7 except for basal narrow pale rings, and with markings on end segments as follows: segment 1 blue except for a blackish basal dorsal twin spot; segment 2 blue with a broad parallel-sided dorsal black band that is narrowly invaded by the blue of the sides toward the apex of the segment and incloses a large middorsal oval spot of blue farther forward; segments 8 and 9 blue except for very narrow black crosslines on their joinings; 10 sim-

ilar, but with these lines widened on dorsum into crossbands that cover most of the dorsum.

Abdominal appendages black above, externally and on terminal teeth; superiors about as long as segment 10, inferiors shorter. Viewed from above the superiors are straight, slightly narrowed to a blunt apex, at the inner side of which is a minute tooth; beneath this tooth the end is dilated below in a flat squarish inflexed plate, and between the two on the end is a little notch that appears more prominently in side view. In lateral view these appendages parallel-sided and blunt; inferiors a little shorter and subpyramidal, with a minute internal tooth just before apex.

Type, a single male specimen "Manila 7 VI 1930 McGregor."

PSEUDAGRION CROCOPS Sélys. Plate 16, figs. 223 and 224.

SÉLYS, Bull. Acad. Belg. (2) 42 (1876) 512; An. Soc. Esp. Hist. Nat. 11 (1881) 27, "Philippines;" KARSCH, Entom. Nachr. 22 (1896) 327; RIS, Nova Guinea 13 (1915) 97, fig., male appendage.

This species we have not seen. It is a large species (hind wing, 28 mm) with the front of the synthorax black, the sides red, the abdomen black with orange markings on segments 9 and 10. We copy (Plate 16, figs. 223 and 224) Ris's figures of the male appendages.

PSEUDAGRION MICROCEPHALUM Rambur. Plate 16, figs. 227 and 228.

RAMBUR, Ins. Neuropt. (1842) 259 (in *Agrion*); SÉLYS, Bull. Acad. Belg. (2) 42 (1876) 504; An. Soc. Esp. Hist. Nat. 11 (1882) 27, Luzon; LAIDLAW, Mem. Ind. Mus. 5 (1915) 179; Rec. Ind. Mus. 12 (1916) 23, fig.; RIS, Suppl. Ent. 5 (1916) 40, 43, 8 figs. of male appendages; FRASER, Rec. Ind. Mus. 16 (1919) 367, nymph; ibid. 24 (1924) 497.

Abdomen, 29 to 30 mm; hind wing, 19.

This widely distributed oriental species is pale blue with three conspicuous black stripes on the thorax, one middorsal and two on the humeral sutures. Top of head blue with a very irregular black cross stripe through the rear ocelli from eye to eye, and three dots (sometimes connected) in a triangle around front ocellus. A spectacled pattern of black surrounding two blue spots on dorsum of prothorax.

Abdomen mostly blue on three segments at each end; segments 7 and 8 blue, except for a very narrow apical ring of black; segment 10 black above for its entire length. Superior appendages (Plate 16, figs. 227 and 228) black, inferiors pale.

PSEUDAGRION FLAVIFRONS sp. nov. Plate 16, figs. 231 to 234.

Male, length, 40 mm; abdomen, 32; hind wing, 19.

Female, length, 41 mm; abdomen, 33; hind wing, 20.

A yellow-faced species, with a 5-striped synthorax and blue-tipped abdomen. Face yellowish, tawny in male, pale yellow in female. Antennæ black, front of two basal segments yellow. Frons all yellow except for a median black dot. Yellow surrounding black-rimmed median ocellus and ending in bottom of a U-shaped black mark between and behind lateral ocelli. A black spot either side of median ocellus; an angulate black streak either side of and in line with paired ocelli; this streak dilated at ends, from each inner end a branch extending obliquely backward to occiput. Behind these streaks postocular areas (not spots) of dull bronzy green extending from eye to eye, narrowly margined behind with black. In the more brightly colored specimens these black-rimmed areas give the top of the head a spectacled appearance.

Prothorax yellowish on dorsum, with a black line across rear of middle lobe and two areas extended forward on that lobe and conjoined to enclose a yellow quadrate area; hind lobe yellow, with a black edging on rear of lateral margin. Synthorax grayish green, striped with black. Three stripes close together, a narrow median stripe covering carina, a wider stripe on each side, conjoined on crest at rear and at collar in front, then extending laterally. A wider stripe covering humeral suture. This stripe even in its middle portion, sinuate and narrowed at both ends. Sides pale greenish olive, with a roundish black spot just above middle of obsolete midlateral suture (sometimes this spot with a tail extending upward), and a black streak in upper part of third lateral suture. Subalar carinæ mostly black-edged.

Wings hyaline, with tawny stigma and brownish veins. Postnodals ten and eight in forewing and hind wing, respectively; front side of quadrangle one fourth and one half length of hind side in fore- and hind wings, respectively.

Legs yellow, with brown spines, femora with stripes of black covering outer sides. Claws yellow, with brown tips.

Abdomen black above, marked with blue, paler below. Dorsum of segment 1 with a quadrate black spot covering its basal half; dorsum of segment 2 blue, with a small black middorsal basal triangle and a goblet-shaped black spot on its apical half.

Base of goblet resting on apical margin of segment, bowl extending forward on a slender stem. On segments 3 to 6 black of dorsum interrupted at base of each segment and constricted with paler just before apex. On segment 7 the black ending jaggedly at two thirds length of segment in a ragged or trifid point. The remainder of segment 7 and all of segments 8, 9, and 10 blue except for carinæ, spines, and joinings. Superior appendages of male (Plate 16, figs. 231 to 234) blackish, inferiors pale, with minute black end tooth on each. Large internal tooth on superiors inclining upward and just visible from side. Another minute tooth halfway from this large tooth to apex.

The female differs in having the black coloration somewhat less extensive though following the same pattern. The large retrorse spines that spring from near the ends of the transverse black line on the prothorax are yellow, with blackish tips. On the abdomen the black of segment 2 is like that of segments 3 to 6, and the sides of segments 8 and 9 are blue, as is also the dorsum of segment 10. The appendages are black, with a yellow edging, or yellow with a black edging.

Type, male, Manila, June 7, 1930.

Allotype, female, from Campus, Los Baños, November 12, 1933 (*J. Tabor, Jr.*).

LUZON, Laguna Province, Los Baños; Pila; Calamba; Bay Bangyas; Rizal Province, Novaliches: Pangasinan Province, Tayug: La Union Province, Naguilian: Ilocos Norte Province, Laoag: Nueva Vizcaya Province. Many males and some females, collected in January, February, April, May, June, November, and December.

PSEUDAGRION EVANIDUM sp. nov. Plate 16, figs. 225 and 226; Plate 20, figs. 292 and 293.

Male, length, 36 mm; abdomen, 29; hind wing, 18.5.

A beautiful turquoise and black species.

Head blue, including eyes, marked with black as follows: Three basal dots on anteclypeus joined by a hairline along frontal suture; antennæ black beyond segment 2; a fairly broad, much broken stripe between eyes across ocelli; a narrow line along occipital border joined to band along edge of eyes and at ocelli, so marking off two large rounded triangular postocular spots with a narrow bar of blue between them.

Prothorax blue, with a black pattern on dorsum which includes two lateral spots and one central-bigeminate blue spot. Synthorax blue, with a broad black stripe on dorsum, a pair of some-

what narrower humeral stripes, a small round dot on middle of side, and a hairline stripe on third lateral suture. Femora black on outer side, blue on inner. Tibiæ and tarsi yellowish, fore tibiæ dark on inner side. Spines black, about as long as distance between them. Wings hyaline, stalked about as far as anal crossing. Postnodals ten or eleven in forewing, eight or nine in hind wing. Stigma dark brown, with a very narrow yellow border, a little more acutely angulated distally than proximally. Front margin of quadrangle a little over one-third length of that of the hind margin in forewing, a little over one-half in hind wing.

Abdomen blue, with a broken middorsal stripe and apical rings of black. Segment 1 with a basal dorsal square spot. Segment 2 with a hastate spot on apical half connected by a stalk with apical ring. Segments 3 to 5 with the stripe starting in a point near base, gradually broadening toward apex, then narrowed to join apical ring. Segments 6 and 7 broader and continuing to widen to end of segment. Segment 8 to 10 entirely blue, except for narrow basal and apical rings of black, broader on segment 10. Terminal black spines on segments 8 and 9. Segment 10 broadly excavate on dorsum of terminal margin. Superior appendages about as long as segment 10, black, bifid at apex in lateral view, in dorsal view broad at tip, and showing a small inner tooth near tip. Inferior appendages less than half length of superiors and sharply angulately truncate.

This species most closely resembles *P. laidlawi* Fraser but differs in the larger size and in the shape of the inferior anal appendages of the male.

LUZON, La Union Province, Naguilian, 9 males, December, 1930 (*Luciano Marzan and A. Estocapio*): Ilocos Norte Province, Laoag, 3 males, January, 1931 (*Manuel Asuncion*).

CŒNAGRION PENDULUM sp. nov. Plate 17, figs. 239, 242, 243, and 246; Plate 21, figs. 300 and 301.

Male, length, 30 mm; abdomen, 25; hind wing, 16.

Female, length, 32 mm; abdomen, 28; hind wing, 17.

A dainty little black and violet-blue species, with black and yellow legs. Face yellow up to level of ocelli, with a black spot just before base of each antenna, a narrow transverse line between but not reaching these spots, and mere touches of brown on median line at junctions of frons and clypeus and of clypeus and labrum, and at outer basal angles of labrum. Antennæ black, except for yellow front of pedicel. A somewhat broader black M-shaped crossline behind middle ocellus, bounding in

front a yellow area that is 3-lobed to rearward, a wide lobe outside each lateral ocellus, and a narrow spur between lateral ocelli. Remainder of top of head black, except for a pair of cuneate postocular yellow spots and a narrow occipital line that does not quite join them.

Prothorax with the intricate pattern of black on yellow shown in Plate 17, fig. 239, in female; in male bands of black a little wider. Synthorax pale violet-blue striped with black as follows: In male a middorsal band a little wider than adjoining pale antehumeral areas, with narrow lines diverging from it on carinæ at both ends; a hairline in humeral suture closely bordered by two incomplete irregular black lines, irregular black line in front widened above, irregular black line behind widened below; descending from subalar carina, another hair line terminating midway on side of thorax in an oval spot (having an appearance that suggested the specific name); below hind wing on third lateral suture a shorter streak. Venter and base of all legs yellow. Black lines in female narrower, middorsal stripe broken into three closely parallel lines. Femora externally broadly black. Tibiæ internally less black. Spines, tips of claws, and joinings of tarsal segments, black. Wings hyaline, with brown veins and paler stigma, the latter twice as long as wide but covering less than one cell. Postnodal crossveins eight and seven in forewing and hind wing, respectively.

Male, abdomen bluish on sides and on segments 8 to 10, with a black middorsal band that is interrupted near apex on segment 1, continuous and broader basally and twice constricted on segment 2, and of similar form on segments 3 to 7; that is, narrowly interrupted at base and a subapical constriction on each. Segments 8 and 9 blue except for hairlines at joinings; segment 10 blue, with a middorsal black line that is dilated at both ends in a somewhat H-shaped figure. Appendages pale except for incised tips. Abdomen of female similar, with less black on dorsum of segment 2. Sides of segments 8 to 10 blue, with a broad black patch covering most of dorsum of segment 8 and half that of segment 9.

This species is nearest *C. barbatum* Needham [20] but notably smaller, with fewer postnodals, with yellowish hairs on face instead of brown, and with many minor points of difference in coloration.

[20] Zool. Sinica 11 (1930) 270, pl. 20, figs. 4, 4*a*.

LUZON, Laguna Province, Los Baños, 2 males and 1 female, October 25, 1931 (*F. Olivares*).

Genus ISCHNURA Charpentier

The two widely ranging species that have been before us from the Islands are very similar in superficial appearance. Segments 8 and 9 of the male abdomen are mainly blue (segment 8 wholly blue) in both, but the black on the dorsum of segment 9 is restricted to the ends of the segment in *senegalensis* and continuous from base to apex in *elegans*. The critical characters are shown in Plate 16. A narrower cleft in the apical hump on segment 10 of *senegalensis*, and an inturned point on the inferior basointernal branch of the superior appendage.

ISCHNURA SENEGALENSIS Rambur. Plate 16, figs. 237 and 238.

RAMBUR, Ins. Neuropt. (1842) 276 (in *Agrion*); SÉLYS, Bull. Acad. Belg. (2) 41 (1876) 273; An. Soc. Esp. Hist. Nat. 11 (1882) 27, Luzon, Cebu, Mindanao; ibid. 20 (1891) 217, Sibul; RIS, Ann. S. Afr. Mus. 18 (1921) 333, figs.; FRASER, Faun. Brit. India 1 (1933) 348, fig., full bibliography.

A common and widely distributed blackish damselfly, with conspicuously shiny metallic-green patches covering postclypeus and segment 2 of abdomen in male. Two round blue postocular spots on black of top of head, labrum bright blue; sides of abdominal segments 1, 2, and 10, and all of segments 8 and 9 except for narrow rings of variable extent at front and rear margins, also bright blue. Apical black ring on segment 9 very variable in extent, almost absent in some of our specimens and wide in others, covering nearly half of dorsum. Cleft apical dorsal margin of segment 10 scarcely elevated above general level in this species.

The superior appendages of male (not well shown in current figures, probably because drawn in a retracted position) palmately broadened beyond base and forked at the end into a stout obtuse outer branch and a long, declined, sigmoid, acute inner branch, nearly as long if directed straight to rearward as inferior appendage. Tips of inner branches of the two appendages convergent.

Numerous specimens from Chamartin, Aug. 12, and a few each for Sobradiel, July 2; Madride, Aug. 1; Alamine, July 13; and Manila, Nov. 9.

ISCHNURA ELEGANS van der Linden. Plate 16, figs. 235 and 236.

VAN DER LINDEN, Opusc. Sci. 4 (1823) 104 (in *Agrion*); SCHMIDT, Thierwelt Mitteleur. 4 (1929) 15, many figs.; FRASER, Faun. Brit. India 1 (1933) 351, figs., full bibliography.

LUZON, Nueva Vizcaya Province, December 26, February 31: Ilocos Sur Province, Candon, January 3: Ilocos Norte Province, Laoag, December 25: Tarlac Province, Tarlac, December 22: Pampanga Province, Magalang, December 27, a few specimens: Laguna Province, Los Baños and vicinity, many specimens.

The nymph of this species has been described by the senior author.[21]

Genus PERICNEMIS Sélys

This little-known genus includes the largest cœnagrionine damselflies in our fauna. Three species have been described, two of them from incomplete males lacking the end segments of the abdomen, and a third from a single female specimen. One of the surprises of this study was the finding of five new species in the material sent us, two of them represented by good specimens of both sexes. This material permits a fuller characterization of the genus than has been possible hitherto. Of the generic characters stated by de Sélys the two emphasized as most distinctive, the 5-sided stigma and the double row of cells following it in the apical costal space, now are seen to hold only for the type species, *P. stictica* Sélys.

Large damselflies, allied to *Amphicnemis* and *Teinobasis,* with similar but more moderate relative length of the abdominal segments and with less basal convergence of veins M_3 and Rs. Vein M_3 arising before subnodus; vein Rs at it, or only a shade beyond. Vein M_1 strongly angulated at stigma, with crossvein at bend forming a triradiate brace, around which the cells are larger than normal. Stigma rhomboidal, narrower in front than at rear. Arculus at second antenodal crossvein. Anal crossing, ac, near level of second antenodal crossvein. Quadrangle rather broad, front side about two-fifths length of posterior side in forewings, three-fifths in hind wings. Between quadrangle and subnodal two crosslines between latter and base of M_2 crosslines varying with species, from three to six. Superior appendages of male longer than segment 10, simple, arcuate, generally longer than inferiors, more or less convergent at tips. The subanal plate bearing a low lateral prominence supporting inferiors. Claws of tarsi lacking the usual inferior denticle (except in *P. mcgregori*).

[21] Dragonflies of China (1930) 283, pl. 18, fig. 17.

Key to the species of Pericnemis.

ADULT MALES

1. Stigma with front side about half as long as rear .... 2.
   Stigma with front side about four-fifths as long as rear .... 3.
2. Black and greenish .... *incallida.*
   Black and yellow .... *bonita.*
3. Lines of crossveins between subnodal and origin of M_2, four and three in forewing and hind wing, respectively .... 4.
   Lines of crossveins six and five in forewing and hind wing.... *flavicornis.*
4. Dorsum of abdomen red; a yellow stripe across rear margin of occiput: labrum with a narrow black border along its basal hinge.... *mcgregori.*
   Dorsum of abdomen black; no yellow stripe across rear margin of occiput; labrum wholly pale .... *cantuga.*

We are tentatively listing below three species that are not included in the key: (1) *Amphicnemis glauca* Brauer, which we have not seen and which is known only from the female type specimen; it is placed here because of its apparent agreement in important characters with the female of *P. flavicornis;* (2) *Amphicnemis lestoides* Brauer, which we redescribe and illustrate with a figure of the male genitalia, and another unnamed species from Los Baños, that is very close to *lestoides* but represented in the collections before us only by two discolored female specimens in alcohol.

Brauer's *Amphicnemis lestoides* differs markedly from all the species of the preceding key in that M_3 and Rs arise in contact at the subnodus, run very close together to the first intervening crossvein where they again fuse, to separate slowly and evenly thereafter (Plate 22, fig. 311). It also differs in having the nodus at one-third the wing length; it is a little farther out in the broader wings of the others. It also differs in having the inferior appendages slightly longer than the superiors. De Sélys set it apart from *Amphicnemis* proper as a new subgenus that he did not name. The proper allocation of these species must await more and better material than has been available to us.

PERICNEMIS INCALLIDA sp. nov. Plate 18, figs. 254 and 255; Plate 22, fig. 305.

Male, length, 59 to 65 mm; abdomen, 50 to 56; hind wing, 34 to 36.

A big smooth greenish-brown species with long blackish abdomen. Head greenish black above, with a white ring around tip of basal antennal segment and a small white streak running

obliquely downward on frons from base of each antenna. Flagellum of antenna brown. Face black and white; postclypeus shiny black, bordered in front and behind with white; anteclypeus white, and also lower margin of frons. Labrum black, basally margined with yellowish-white in front, and invaded by a pair of oblique pale streaks from rear. Occiput narrowly margined with dull yellow on its straight midborder, and more broadly margined on bulge behind eyes.

Prothorax obscure greenish above, paler beneath, front border narrowly blackish. The hinder lobe broadly expanded to rearward in a scooplike plate that overlies front of mesothorax and again expanded in a blunt laterally directed process on each posterolateral angle. Both expansions thin and platelike, not spinelike. Synthorax greenish or brownish with an overcast of green, dark on dorsum, gradually paling downward to yellowish sternum, without pattern.

Legs yellowish, with brown spines. A brown external line on all femora, expanding at end to surround knees, three tarsal segments severally tipped with brown. Larger spines in the outer rows on the femora two, four, and six on forelegs, middle legs, and hind legs, respectively.

Wings hyaline and strongly iridescent. Postnodal crossveins fifteen and thirteen in forewing and hind wings respectively. Crosslines between base of subnodal and base of M_2 six and five in forewing and hind wing, respectively. Stigma rhomboidal, about half as long in front as behind in both wings.

Abdomen brownish above, darkening toward tip, becoming yellowish on sides, more broadly on segments 1 and 2 (greenish yellow), and on segments 8, 9, and 10 (brownish yellow). Appendages brown, paler internally, equal in length, simple; bowed superiors with a median inferior platelike dilation that extends across their concave under side like the cord of a bow.

LUZON, Laguna Province, Los Baños, 1 male (*F. Juan*), 2 males, April 19 (*F. Juan*): Tayabas Province, Quezon Park, 1 male, May 3 (*F. Juan*). SAMAR, 1 male, smallest of the lot, June 2 (*McGregor*).

PERICNEMIS BONITA sp. nov. Plate 18, figs. 260 and 261; Plate 22, fig. 306.

Male, length, 61 mm; abdomen, 53; hind wing, 31.

Female, length, 55 mm; abdomen, 45; hind wing, 32 to 35.

A yellow and black species in the male, greenish olive and black in the female. Head of male velvety black above, black overlaid with a pair of large greenish triangles on broad slopes adjacent to eyes. In front of these triangles a pair of curved

yellow streaks lying with their pointed inner ends toward ocellar triangle. Outer face of the two basal segments of antennæ yellow: a black inverted U-shaped spot covering most of postclypeus, with a faint black dash extending from its base around lateral margin of that sclerite. Labrum rotund, bright yellow, with a blackish streak on its basal lateral margins. Occiput yellow-margined from eye to eye, yellow widened on straight middle portion, with three small divergent spurs of that color projecting forward into the black.

Prothorax yellow, black across edge of front lobe and in a blotch on each side of middle lobe. The hind lobe slightly produced backward in middle, but posterolateral angles long and blunt. Synthorax bright yellow, with a deep black middorsal stripe on front that is completely divided by a yellow carina. This stripe narrow in its upper portion, forked at top where it runs out laterally along crest, greatly widened at front where it runs down laterally to mesepisternum. Touches of brown about wing roots.

Legs yellow, with brown spines and touches of brown above and below knees. Large spines of outer row three, four, and five on fore, middle, and hind femora, respectively. Wings hyaline; postnodal crossveins sixteen and fourteen in forewings and hind wings, respectively. Crosslines between subnodal line and base of M_2 six or seven and five or six in forewing and hind wing, respectively. Stigma rhomboidal, with front side a little more than half as long as hind in both wings.

Abdomen blackish above, the black deepening to rearward and spreading down the paler sides until it almost covers segments 7 to 10; yellow beneath. Appendages brown, paler within. Subanal plate with a nipple-shaped lateral prominence.

Female much less brightly colored, synthorax greenish olive, darker but without pattern middorsally. Postclypeus wholly black; other head markings less distinct than in male. Wing membrane slightly tinged with brownish, the long ovipositor yellow.

LUZON, Laguna Province, Mount Maquiling, 1 male and 1 female, January 28, 1930 (*A. C. Duyag*), 1 female, April 23, 1930 (*A. C. Duyag*), 1 male, May 27, 1930 (*A. C. Duyag*).

PERICNEMIS MCGREGORI sp. nov. Plate 18, figs. 256 and 257; Plate 21, fig. 303.

Male, length, 52 mm; abdomen, 44; hind wing, 25 to 26.

A bronzy, yellow-legged species, with a blackish abdomen that widens at the tip with a trumpetlike flare and bears hook-shaped

superior appendages. Head bronzy black above, with black antennæ that are white-ringed on the basal segment. Circular labrum green, with a narrow black basal hinge line, from which a short median streak of the same color projects forward. Ante- and postclypeus greenish, mottled with black. Occipital border yellow-margined only in the middle.

Prothorax olive-green above, overlaid in the middle with yellowish. Hind lobe narrow, not at all produced at hind angles. Synthorax yellowish olive, more yellowish in region of humeral suture, without definite pattern.

Legs yellow, including spines and claws, with no striping; knees only faintly darker. Claws beneath bearing a distinct denticle. Femoral spines of outer row three, four, and six on forelegs, middle legs, and hind legs, respectively. Wings hyaline with brown veins and golden bronze stigma bordered by a yellow line within the heavy veins. Stigma rather regularly quadrangular, front margin almost as long as rear. Postnodal crossveins thirteen and eleven in forewings and hind wings, respectively. Crosslines between nodal and base of M_2 four and three, fore and hind. Veins M_3 and Rs wide apart at origin, latter at subnodus, but moderately approximated on first intervening crossvein.

Abdomen brown above, this color overspreading apical segments but leaving sides of segments 1 and 2 yellow. Segments diminishing in length from middle outward, length of segments 7 to 10 approximately 10 : 4 : 3 : 2. The last three segments wider, with a trumpetlike flare to rearward. Sigmoid inferior appendages longer than segment 10, much shorter than hooked superiors. These appendages black, hooked superiors brownish at base and within. Subanal plates densely clad with golden hairs, each bearing at the outer side a low pyramidal tubercle.

There are two male specimens of this unique species.

LUZON, Laguna Province, Ube, 2 males, April 24, 1930 (*McGregor and Celestino*).

This species is tentatively placed here for want of a better location, although it differs from the others described above in the form of rear end of abdomen and appendages, in the wider separation of M_3 and Rs at the origin, in the form of the stigma, and in having a distinct denticle under the tip of the tarsal claws.

PERICNEMIS FLAVICORNIS sp. nov. Plate 18, figs. 262 to 264; Plate 21, fig. 304.

Male, hind wing, 32 mm.

Female, length, 45 mm; with abdominal segments 7 to 10 missing; hind wing, 31.

A black and green species, with hyaline wings and yellowish-margined stigma.

Head black above, middle of occipital border narrowly yellow, an isolated yellow spot before base of each antenna. The same color ringing apex of antennal segment 1 and covering front of segment 2. Face bluish green, with two broad black cross stripes, one across base of labrum, the other covering postclypeus. Front margin of labrum narrowly yellow and fringed with long stiff hairs of same color. Rear of head and under side of mouth parts bluish green.

Prothorax brown across middle lobe, greenish at sides, with a narrow black line on anterior margin of front lobe, and a wide black band covering straight-edged hind lobe except at ends. Ends projecting laterally, then turning backward with the slant and curvature of the horns of the water buffalo, yellowish. A broad middorsal black band covering front of synthorax narrowly divided by a yellow line on carina, five yellow lines on edges of crest, both within and without. Sides obscurely clouded with bluish green, deeper green on subalar carina. Venter yellowish.

Legs yellow. Femora with a streak of brown on dorsal side that expands into a spot at the knees. Spines brown. Orange claws toothless or with a scarcely discernible rudiment of the usual inferior tooth beneath tip. Wings hyaline-iridescent, with a brown stigma bordered by heavy fuscous veins that are narrowly margined within by a line of yellow, and also without on the inner and posterior sides. Postnodal crossveins fourteen or fifteen and thirteen or fourteen on forewing and hind wing, respectively. Arculus at second antenodal. Vein M_3 arising a little before subnodus, Rs at or its own diameter beyond, the two veins converging and closely approximated at first intervening crossvein. Between subnodus and base of R_2 seven lines of crossveins in forewing and five in hind wing. Quadrangle half as long on front border as on hind border in forewing, two-thirds as long in hind wing. Anal crossing, ac, almost at level of second antenodal, a trifle shorter than inner end of quadrangle.

Abdomen black above from end to end, width and intensity of this color increasing to rearward until it almost completely overspreads segments 8 to 10. Side of segment 1 bluish green with a narrow black line on apical transverse carina; segment 2 of same color in its basal half, beyond which it is yellow. Segments 3 to 5 missing from this specimen: 6 broadly yellowish

beneath, 7 obscurely so; 8 and 9 narrowly so; segment 10 again more broadly so, especially at base and rearward to black marginal ring. Appendages of the form shown in Plate 18, figs. 262 and 263, superior strongly bowed and obliquely placed, both pairs convergent at tips and both bright yellow with black tips.

The female differs in having an extra pair of minute oblique hyphen-shaped yellow marks on the top of the head midway between the eyes and the ocelli, and a little less black pigment on the labrum and elsewhere. It agrees closely with Brauer's description of his *Amphicnemis glauca* in structure and proportions of the apical segments of the abdomen, but differs in color, having no blue on the dorsum of these segments which are black above to the end.

LUZON, Mountain Province, Baguio, 1 male and 1 female (*Lt. Col. Robinson, U. S. A.*)

PERICNEMIS CANTUGA sp. nov. Plate 18, figs. 252 and 253; Plate 22, fig. 307.

Male, abdomen, 59 mm; hind wing, 30.

A larger species than the preceding but similar to it except in minor details that I take to be specific. Unfortunately the body colors are lost in the single alcoholic specimen available, but the head pattern, venation, and the male appendages will serve for recognition.

Head greenish black above, with a pair of small yellow streaks between antennæ and lateral ocelli. Apex of basal antennal segment ringed with whitish. Pale hue of face extending upward to base of antennæ. Postclypeus pale, traversed with two blackish crossbands, anterior crossband wider. Anteclypeus pale, marked with black on its four corners, from middle of its front margin a black dash extending forward a little way across greenish labrum. Straight middle portion of occipital border narrowly margined with yellow.

Flat hind lobe of prothorax narrowly margined with yellow. Body colors lost in alcohol. Legs wholly yellow, including spines and claws. Wings hyaline. Postnodal crossveins fourteen and thirteen in forewing and hind wing, respectively; crosslines four and three between subnodal and base of M_2.

Abdomen blackish, darkening apically, paler beneath. Yellow of underside of segment 10 extending in a large square area upward on sides of segment, but not reaching apical margin; outrolled edge of apical margin black, this color extending upward and across the elevated and basally emarginate middorsal border. Appendages yellow except for their incurved toothlike

tips, these tips minute on superiors but very much larger and offset by a groove on inferiors.

The species seems to differ from *P. mcgregori* in much larger size, in having yellow streaks on the vertex and a yellow hind margin on the prothorax, and in the form of the tips of the appendages.

MINDANAO, Surigao Province, Mount Cantugas, 1 male, the type, in alcohol, March 17, 1931 (*A. C. Duyag*).

PERICNEMIS GLAUCA Brauer.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 542 (in *Amphicnemis*), female, Luzon; SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 121 (in *Telebasis*); Ann. Soc. Esp. Hist. Nat. 11 (1888) 28 (in *Telebasis*), Mindanao.

This species we have not seen. It is known as yet from a single female specimen. Brauer's description of that specimen indicates close agreement, except for minor details, with the female of our *P. flavicornis*. For that reason we are tentatively transferring the species to this genus. The front of the stigma is hardly shorter than the rear. There are eighteen postnodal crossveins. The synthorax is bluish in front, with a yellow carina. The abdomen is blackish above, with segment 8 partly and segments 9 and 10 wholly blue. In this coloration of the end segments *glauca* differs markedly from the female *flavicornis*, which has them wholly blackish above. The hind wing of *glauca* measures 29 mm.

PERICNEMIS LESTOIDES Brauer. Plate 18, figs. 258 and 259; Plate 22, fig. 311.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 541 (in *Amphicnemis*), Mindanao; SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 130 (in *Amphicnemis*); An. Soc. Esp. Hist. Nat. 11 (1882) 29 (in *Amphicnemis*).

Male, abdomen, 48 mm; hind wing, 29.

A black-backed species, with long yellow abdominal appendages. Head entirely black above. Vertical face of frons with an isolated yellow transverse stripe that is divided by black in the middle. Postclypeus black. Anteclypeus and mandibles pale, marked with diffuse spots of brown. Labrum shiny black, a broad front border of yellow, and a fringe of long yellow hairs.

Prothorax shiny greenish black above, yellow beneath; an isolated stripe of yellow across frontal lobe, yellow of coxæ, narrowly invading lower edge of black above them. Black hind lobe produced, elevated in a low obtusely triangular plate. Synthorax entirely shiny black in front, down to midlateral suture

and a little farther at ends; down on mesinfraepisternum below, back to hind wing roots above.

Legs yellow, with a brown line on back of femora (expanded at knee to form a half ring) on inside of tibiæ with reddish brown spines and claws. Five long spines in outer row on middle and hind femora. Wings hyaline, with brown veins and pale-brown stigma, bordered with paler inside heavy marginal veins and obliquely placed, and about three-fifths to four-fifths as long in front as behind. Postnodals fourteen. Crosslines between subnodal and base of M_2 seven and five in forewing and hind wing, respectively. Base of M_3 slightly before (sometimes at) subnodus, where Rs also originates, the two running almost parallel and very close together to their union (and, sometimes their consolidation) upon first intervening crossvein.

Abdomen black above, darkening toward tip, with segment 10 above becoming shiny greenish black; yellowish beneath. Length of last four segments 10 : 4 : 3 : 2. Appendages and anal plates light yellow, nearly twice as long as segment 10, slightly tapered outward from their diverging bases, then extended parallel to their tips, which end in single brownish converging denticles. Inferiors very slightly longer than superiors, both, as Brauer described them, long and finger-form.

MINDANAO, Surigao Province, Mainit, 2 males, April, 1931 (*A. C. Duyag*).

PERICNEMIS sp?

At least one additional smaller species, represented by imperfect specimens, but having the excessive length of the abdomen, the form of the wing, and the basal conformation of veins M_3 and Rs of *P. lestoides*, is before us.

LUZON, Laguna Province, Los Baños, 2 females in alcohol, April 24, 1931 (*F. Juan*).

AMPHICNEMIS FURCATA Brauer.

BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 543 (no locality); SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 127; An. Soc. Esp. Nat. Hist. 11 (1882) 29.

Male, abdomen, 37 mm; hind wing, 21.

This species we have not seen. The position of vein M_3 at origin (just beyond the subnodus) and the excessive length of the abdomen as compared with that of the hind wing would seem to ally it to *Teinobasis*. The shape of its stigma (one

third shorter in front than behind) is like in *Pericnemis,* and the long S-shaped processes springing from the outer angles of the hind lobe of the prothorax are very peculiar. A definitive generic allocation must await new and adequate material for study.

De Sélys referred Brauer's *A. glauca* to *Teinobasis.* Possibly this was a mistake. He may have intended to so transfer *A. furcata* to that genus.

Genus TEINOBASIS Kirby

These are slender damselflies with extreme elongation of the middle abdominal segments, so that the abdomen is very much longer than the wings. The legs are rather short and weak, with rather few spines of very moderate length. The side pieces of the synthorax are very strongly aslant, making an angle with the perpendicular of at least 75°.[22]

Wings stalked beyond level of middle of quadrangle, the portion beyond unusually narrowed, resulting in basal convergence or consolidation of veins M_3 and Rs.

This convergence is at the first intervening crossvein in one group of species, these veins remaining well apart at their origin.[23] The fusion is more or less complete from the middle fork out to or beyond that crossvein in the remaining species. The arculus is generally a little beyond the second antenodal crossvein, and the base of vein M_3 is generally beyond the subnodus. Between the quadrangle and the line of crossveins descending from the subnodus there are two other crosslines of them.

The tip of the male abdomen is peculiar in two respects. The middorsal apical margin of segment 10 is depressed in a shelflike semicircle from the floor of which may arise a pair of minute teeth. The appendages appear to be in three pairs, and this appearance has given rise to diverse interpretations of homologies. Both Brauer and de Sélys thought the inferior appendage to be deeply branched; also, latterly, Lieftinck.[24]

[22] The maximum skewness of this angle as recorded by Needham and Anthony [Journ. N. Y. Ent. Soc. 11 (1903) 123] for Odonata in general was 72° in *Aciagrion.*

[23] This type of vein behavior is further evolved in *Paramecocnemis* [Lieftinck, Nova Guinea 15 (1932) 21, fig. 9], veins M_3 and Rs being confluent for a distance of nearly two cells beyond the subnodus while remaining well apart at their bases.

[24] Nova Guinea 15 (1932) 582.

Both Ris and Campion thought the upper one was deeply branched. May not the lower one be the uniquely pointed, elongated, and chitinized apex of the subanal plate, extended beneath and supporting the slender inferior appendage? The unique feature in this genus seems to be that thus the subanal plate is pressed into service as a copulatory organ. A more careful study of homologies is needed for these parts.

Of the seven species hitherto described from the Philippines five have been before us, and in addition, four others that appear to be new. The ten appear to be distinguishable by the characters stated in the key below. However, the ultimate criteria of the species will be found in the form of the genitalia of the male, and these we have figured in so far as they are available in our material.

Key to the species of Teinobasis.

1. Veins M_3 and Rs widely separated at origin but converging at once upon first intervening very much shortened crossvein .... 2.
   These veins fused in a common point at origin and generally fused for a first cell length; first crossvein eliminated by the fusion .... 5.
2. Dorsum of synthorax metallic black; a blunt tooth arising from middorsal carina .... *dentifer.*
   Dorsum of synthorax red or yellow .... 3.
3. Small species (hind wing, 20 mm); superior appendage with an internal toothlike prominence: head and abdominal segment 1 greenish above. *filiformis.*
   Larger species (hind wing, 23 to 26 mm); no green color .... 4.
4. Postclypeus and top of head black .... *filum.*
   Postclypeus and top of head reddish .... *filamentum.*
   Postclypeus pale; a crown-shaped black line between the antennæ..*corolla.*
5. Anal crossing nearer second antenodal than first; basal fusion of veins M_3 and Rs incomplete for first interval .... 6.
   Anal crossing nearer first antenodal than second: basal fusion of veins M_3 and Rs complete .... 7.
6. Tip of male inferior appendage and appendagelike subanal plate divergent; superior appendage bilobed at apex .... *nigra.*
   Tips of these appressed: superior appendage entire at apex.... *strigosa.*
7. Abdominal segment 7 of male pale in its apical half .... *recurva.*
   Abdominal segment 7 blackish .... 8.
8. Abdominal segments 8 and 9 of male bluish .... *samaritis.*
   Abdominal segments 8 and 9 of male blackish .... *olivacea.*

TEINOBASIS DENTIFER sp. nov. Plate 19, fig. 278; Plate 21, fig. 299.

Female, length, 48 mm; abdomen, 41; hind wing, 25.

A bronzy black species with pale legs that bear a few strong spines. Head bronzy black above, with a low straight occipital border and a conic prominence arising between eye and occiput. Face yellowish, crossed by two broad black transverse bands,

one covering basal half of labrum, the other the postclypeus. Yellow of edge of frons widened upward at edge of eye.

Entire thorax metallic greenish black above, pale yellowish below. Middle lobe of prothoracic dorsum smooth, anterior lobe a low ridge, posterior lobe very peculiar, with broadly triangular middle portion inclined to rearward and bilobed at tip, and its lateral extension erect and denticulate at tip. On middorsal carina of synthorax at about one fourth its height arises a blunt tooth that is directed straight forward. Bronzy green of synthorax extending down the sides evenly almost to middle coxa at front and to hind wing roots at rear.

Legs yellowish; femora indistinctly streaked with brown externally, middle and hind femora bearing each four stout spines in external row, tibiæ five, with a smaller additional at end.

Wings hyaline with brown veins. Postnodal crossveins 14 and 12 in forewings and hind wings, respectively. Arculus at second antenodal; anal crossing at almost same level. Vein M_3 arising at subnodus, Rs a little farther out. These two veins converging abruptly to a short crossvein and then slowly diverging, with six and four (forewing and hind wing) lines of crossveins intervening before origin of M_2. Stigma about as wide as long in front, a little longer on hind margin, especially in forewing.

Abdomen brown above, paler beneath. Dorsum of segment 1 almost covered by a black crescent that is broadly concave to rear; segment 2 blackish with greenish reflections; segments 3 to 7 brown, dorsum darkening, sides becoming more yellowish to rearward; segments 8 and 9 mainly yellow at sides, the fuscous forming merely a broad dorsal stripe, with an isolated fuscous streak at base of ovipositor; segment 10 black, except for a narrow pale apical margin. Supra-anal plate black. Appendages pale brown, ovoid, pointed, about as long as segment 10, a little surpassing pale subanal plates.

There is a single adult female from Davao Province, Mindanao. It is in a broken condition but shows the characters that will serve for specific recognition. Its type of coloration is not that of any of the known females from Mindanao.

TEINOBASIS FILUM Brauer. Plate 19, figs. 275 and 276.

> BRAUER, Verh. zool.-bot. Ges. Wien 18 (1868) 545, male, Mindanao (in *Amphicnemis*); SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 124 (in *Telebasis*); An. Soc. Esp. Hist. Nat. 11 (1882) 543 (April 5 to September 8).

Male, abdomen, 38 mm; hind wing, 23.

We have a single male specimen, bearing no locality label but dated February 11, 1930, and collected by F. Rivera. Was it from Mindanao? Abdominal segments 8 to 10 are reddish and not blackish as described by Brauer; but that and a less extensive darkening of the face is probably due to immaturity. The appendages are shown in Plate 19, figs. 275 and 276.

TEINOBASIS NIGRA Laidlaw. Plate 19, figs. 273, 274, and 287; Plate 22, fig. 309.

LAIDLAW, Proc. Zoöl. Soc. Lond. (1928) 136–138, male.

Abdomen, 36 mm; hind wing, 21.5.

This species, which has been known hitherto from a single male specimen, is very abundant in Luzon. We have many specimens of both sexes, mostly collected about Los Baños, Laguna Province, and Novaliches, Rizal Province. It is a rather small blackish species with yellowish legs streaked with black externally on the tibiæ and across the apices of the tarsal segments. The female has the top of the head mostly black like the male, but the body is paler, the thorax olivaceous, the abdomen fuscous above, paler beneath, tending toward a rich reddish brown on segments 8 to 10, including the ovipositor. The appendages of the male are shown in Plate 19, figs. 273 and 274.

Many specimens, both male and female, from numerous localities in Luzon.

TEINOBASIS FILAMENTUM sp. nov. Plate 19, figs. 277, 285, and 286; Plate 21, fig. 298.

Male, length, 50 mm; abdomen, 45; hind wing, 25.

Female, length, 45 mm; abdomen, 40; hind wing, 26.

An exceedingly slender clear-winged species with blackish abdomen.

Male.—Head all red except eyes and a minute point at each end of labial hinge, paler beneath. Labrum fringed with stiff golden hairs.

Thorax all red except for a black point at each wing root and another at junction with abdomen on each side. Legs red, including spines and claws. Wings hyaline, with brown veins and stigma. Arculus beyond second antenodal crossvein. Postnodals fifteen and fourteen in forewing and hind wing, respectively. Vein M_3 arising a little beyond nodus; Rs a distance beyond that. These two veins converging strongly to first intervening crossvein, which is very short, hardly longer than the diameter of a vein. Beyond them and before the base of M_2 intervening crossveins six in forewing and five in hind wing.

Crossvein ac about twice its length before level of second antenodal. Wing stalked beyond middle of quadrangle.

Abdomen with segments 7 to 10 excessively attenuated. Segments 1 and 2 and base of segment 3 red, with only shaft of penis black. A blackish band covering dorsum of segment 3 beyond base to segment 7, narrowed at base and widened toward apex of each segment. Venter pale yellowish. Segments 8 to 10 blackish, 8 and 10 paler beneath. Segment 10 slightly notched in middle of black-edged posterior dorsal margin. Appendages brown, superiors two-thirds as long as inferiors, superiors ( )-shaped as viewed from above, with broadened bases and blunt tips. The somewhat paler inferiors straight, with spindle-shaped and sharply pointed tips. Viewed from the side the superiors arch upward from the base and the inferiors downward. Beneath the latter the subanal plates carrying a stout process as long as superiors and twice as wide as inferiors, obliquely truncate on end to form a sharp downwardly directed tip. This process was misinterpreted by Brauer as a lower branch of the inferior appendages.

Female.—Female similar to male but paler on head and thorax and the brown of dorsum of abdomen diffusely covering dorsum of basal segments. On the face a pair of little streaks of black on ends of labral hinge, another convergent pair descending from base of antennæ. The female carries three conspicuous black points that the male seems entirely to lack, two on the outer angles of a thin plate that rises erect from the transverse carina at the front of the mesothorax, and a third on the midventral line between the bases of the middle legs. Both front and rear margins of the prothoracic dorsum rise in thin erect ridges, the anterior broadly rounded, the posterior truncate.

This species is nearly allied to *T. filum* Brauer, from which it differs in the larger size, in having face and top of head yellow, and in the form of the male appendages.

We have a single pair from Kolambugan, Mindanao, May.

TEINOBASIS COROLLA sp. nov. Plate 19, figs. 271, 272, and 288.

Male, abdomen, 41 mm; hind wing, 24.

A slender species with reddish head, yellow legs, darkening abdomen, and a black crown spot on its head. Head otherwise yellow, including labrum and postclypeus. Antennæ blackish with apical yellow rings on the two basal segments. Crown spot continuous across prominence of frons, invaded from rear by

three yellow spots. Black borders of middle triangular yellow spot conjoined in rear around middle ocellus.

Thorax entirely reddish except for the two usual black points at the roots of forewing and hind wing, and at the junction with the abdomen on each side. Legs wholly reddish yellow, including spines and claws. Wings hyaline, with brown veins and black stigma. Postnodal crossveins thirteen and eleven or twelve in forewing and hind wing, respectively. Front side of quadrangle half as long as hind side in forewing, two-thirds as long in hind wing. Vein M_3 arising just beyond subnodus, Rs much farther out, the two almost or quite conjoined on the first intervening crossvein. Stigma parallel-sided, or a trifle shorter in front than behind in the forewing only. Between the nodal line of crossveins and the base of M_2 there are in the forewing six and in the hind wing five crosslines. Anal crossing a little nearer to second antenodal than to first.

Abdomen all reddish yellow on two basal segments (except for the shaft of the penis which shows by transparency and is black) and pale beneath to a lessening degree beyond, with wideening of pale color at extreme base and at apex on segments 3 to 7. Segments 3 to 10 black above, the black on segment 9 expanded downward from apex in a diffuse blotch covering most of sides of segment. Appendages black, and of the form shown in Plate 19, figs. 271 and 172.

Female similar to male but paler. Crown stripe between bases of antennæ broken in middle into two U-shaped marks that lie next to antennæ, abdomen not black above beyond two basal segments but only a little darker than they are.

This species is close to *T. filum* and *T. filamentum*, but differs in the crown spot, in the blotch of black on the sides of abdominal segments 9, and in the form of appendages.

Two males, one with the tip of the abdomen missing, from Cavite.

LUZON, Rizal Province, Makabud, 1 female, collector unknown.

TEINOBASIS STRIGOSA sp. nov. Plate 19, figs. 281 and 282.

Male, length, 52 mm; abdomen, 43; hind wing, 27.

Female, length, 48 mm; abdomen, 39; hind wing, 26.

A slender blackish species overcast with dull metallic green. Head in male wholly greenish black above and on face except for two pale cross stripes, one covering anteclypeus and the other on frontal suture. Margin of matt black labrum fringed with coarse hair. Surface of postclypeus shiny black. The two basal segments of antennæ streaked with yellow.

Prothorax greenish above and pale beneath, synthorax the same, with dark on dorsum farther overspreading sides, but with no definite color pattern. Legs pale, armed with brown spines and with touches of brown on knees, on rear of front femora, and on tarsal segments. Wings subhyaline, iridescent, with dark-brown veins and stigma, pale-margined within its heavy bordering veins. Postnodal crossveins fifteen and fourteen in forewing and hind wing, respectively. Quadrangle less than half as long on front as on rear border in forewing, three-fifths as long in hind wing. Anal crossing, ac, unusually near level of arculus. Basal fusion of veins M_3 and Rs often incomplete, but variable. Always these veins seem to arise at a common point and become completely fused at the bend, eliminating the crossvein there.

Abdomen blackish above for its entire length, with rings of deeper color on apical circular carinæ of all segments; yellowish beneath, more broadly on segments 1 and 2, and in large isolated pale blotches on sides of segments 8 and 9. These diffuse pale areas not extending to end of these segments, where the sides are broadly black. Appendages (Plate 19, figs. 281 and 282) black; under side of subanal plate yellowish. Slender abdomen becoming widened on segment 7 to a clavate tip.

Female similar to male in head coloring except that the black of the clypeus is diluted and the labrum is mostly reddish yellow, only a basal line on hinge with three streaks extending forward from it are black. Two of these streaks marginal, the other median. Thorax wholly pale reddish yellow, with only dorsal sutures brownish. Legs as in male. Abdomen colored much as in male but paler—much paler on terminal segments, their apical margins and ovipositor yellow. A longitudinal streak of brown on sides of segment 8 above base of ovipositor.

A number of males and a few females from southern Luzon.

TEINOBASIS RECURVA Sélys. Plate 19, figs. 283 and 284.

SÉLYS, Bull. Acad. Belg. (2) 43 (1877) 114, Mindanao, male (in *Telebasis*); An. Soc. Esp. Hist. Nat. 11 (1882) 28, Mindanao; ibid. 20 (1891) 218, Sibul, Bulacan; RIS, Denkschr. med-naturwiss. Ges. Jena 13 (1908) 103.

We have a single male specimen rather larger than the type (hind wing 26 instead of 23 to 24 mm) and much infuscated with age but still showing the distinctive characters cited by de Sélys in the original description: Abdominal segment 7 pale in apical half except for a black transverse apical carina; apices

of inferior appendage and subanal plate (his two branches of the former) divergent. It comes from Santiago, Agusan, Mindanao, and was collected in April, 1931.

Its genitalia most strongly resemble those of *T. strigosa.*

TEINOBASIS SAMARITIS Ris. Plate 19, figs. 279 and 280.

RIS, Denks. med.-naturwiss. Ges. Jena 13 (1908) 103, male and female, Catbalogan, Samar, April 19 to 26, fig. of male appendage.

Male, abdomen, 39 mm(?); hind wing, 24.

Female, abdomen, 40 mm; hind wing, 25.5.

In the freshest of the specimens of this species abdominal segments 8 and 9 are distinctly paler than the others (probably blue in life). Old infuscated specimens are specifically identifiable by the caudal appendages of the males. They are shown in Plate 19, figs. 279 and 280.

Many specimens from Luzon and 1 male from Kabasalan, Zamboanga Province, Mindanao.

TEINOBASIS OLIVACEA Ris. Plate 19, figs. 269, 270, and 289; Plate 22, fig. 308.

RIS, Denkschr. med.-naturwiss. Ges. Jena 13 (1908) 102, male and female, figs. of wing and male appendages, Naujan, Mindoro.

Male, abdomen, 42 mm; hind wing, 26.5.

Female, abdomen, 40 mm; hind wing, 27.

This species and the preceding are very similar in general appearance (at least in old discolored specimens such as have been before us), and are readily separable only by the form of the terminal appendages of the male, which are distinctive. Both were figured by Ris in the work above cited.

Many specimens from various localities in Luzon.

SUMMARY

In the foregoing pages and in Part I, Anisoptera, there are recognized 153 species of Odonata distributed in 74 genera, including 25 new species and 3 new genera; also *Nannophya pygmæa,* that was mentioned in Part I merely as regional, but that has since been reported from Kolambugan, Lanao Province, Mindanao, May, 1932. The most unexpected find is that of 5 new species of the little-known genus *Pericnemis,* not hitherto reported from the Islands at all.

Described and illustrated are the nymphs of 17 species that have not heretofore been made known. The most interesting and significant of these new nymphs are *Heteronaias* in Anisoptera, and *Rhinagrion* and *Prionocnemis* in Zygoptera.

ERRATA IN PART I

Page 21, line 6 last letter, *for* n *read* m.
57, last heading, *for* ODIOPHYA *read* IDIOPHYA.
81, line 7, *for* in *read* on.
97, Fig. 20, *for* female *read* male.
100, Text fig. 1 at bottom line 3, for ***savi*** read ***sayi.***

ILLUSTRATIONS

[Plates and figures are numbered continuously through Part I, Philip. Journ. Sci. 63 (1937) 21, and the present paper.]

PLATE 11

PLATE 12

PLATE 13

FIG. 159. *Neurobasis luzonensis* Sélys, nymph, prothorax, head, and antennæ.
160. *Devadatta filipina* sp. nov., wings.
161. *Neurobasis luzonensis* Sélys, nymph, inner view of mandible.
162. *Neurobasis luzonensis* Sélys, caudal gills of nymph, lateral view.
163. *Rhinocypha turconii* Sélys, base of wing. *C*, Costa; *Sc*, subcosta; *R*, radius; *M*, media; *Cu*, cubitus; *A*, anal vein; *ac*, anal crossing; *p*, point at which wing stalk begins; *ar*, arculus; *q*, quadrangle; *sq*, subquadrangle; *Mf*, middle fork; *ma*, medioanal link. Arabic numerals designate branches.
164. *Neurobasis luzonensis* Sélys, male, anal appendages, dorsal view.
165. *Neurobasis luzonensis* Sélys, male, anal appendages, lateral view.
166. *Vestalis melania* Sélys, male, anal appendages, dorsal view.
167. *Vestalis melania* Sélys, male, anal appendages, lateral view.
168. *Devadatta filipina* sp. nov., anal appendages, dorsal view.
169. *Devadatta filipina* sp. nov., anal appendages, lateral view.
170. *Neurobasis luzonensis* Sélys, labium of nymph.

PLATE 14

FIG. 171. *Prionocnemis serrata* Sélys, color pattern, male.
172. *Prionocnemis serrata* Sélys, color pattern, female.
173. *Prionocnemis serrata* Sélys, female, top of prothorax, viewed from the front.
174. *Prionocnemis ignea* Brauer, female, top of prothorax, viewed from the front.
175. *Prionocnemis rubripes* sp. nov., male, anal appendages, lateral view.
176. *Prionocnemis rubripes* sp. nov., male, anal appendages, dorsal view.
177. *Prionocnemis hæmatopus* Sélys, female, top of prothorax viewed from the front.
178. *Prionocnemis erythrura* Brauer, male, anal appendages, lateral view.
179. *Prionocnemis erythrura* Brauer, male, anal appendages, dorsal view.
180. *Prionocnemis atropurpurea* Brauer, female, top of prothorax viewed from the front.
181. *Prionocnemis appendiculata* Brauer, male, anal appendages, lateral view.
182. *Prionocnemis appendiculata* Brauer, male, anal appendages, dorsal view.
183. *Prionocnemis rubripes* sp. nov., female, top of prothorax, viewed from the front.
184. *Prionocnemis serrata* Sélys, male, anal appendages, lateral view.
185. *Prionocnemis serrata* Sélys, male, anal appendages, dorsal view.
186. *Prionocnemis serrata* Sélys (supposition), nymph, tip of lateral lobe of labium.
187. *Prionocnemis artopurpurea* Brauer, male, anal appendages, lateral view.
188. *Prionocnemis atropurpurea* Brauer, male, anal appendages, dorsal view.

189. *Prionocnemis hæmatopus* Sélys, male, anal appendages, lateral view.
190. *Prionocnemis hæmatopus* Sélys, male, anal appendages, dorsal view.
191. *Prionocnemis serrata* Sélys (supposition), nymph, median caudal gill.
192. *Prionocnemis serrata* Sélys (supposition), nymph, labium.
193. *Prionocnemis serrata* Sélys (supposition), nymph, lateral caudal gill.
194. *Prionocnemis serrata* Sélys, male wing.
195. *Prionocnemis serrata* Sélys, female, tip of wing.
196. *Prionocnemis atropurpurea* Brauer, male, tip of wing.

PLATE 15

FIG. 197. *Drepanosticta lymetta* Cowley, male, anal appendages, dorsal view.
198. *Drepanosticta lymetta* Cowley, male, top of prothorax viewed from the front.
199. *Drepanosticta sundana* Krüger, nymph, labium. (After Lieftinck.)
200. *Drepanosticta lymetta* Cowley, male, anal appendages, lateral view.
201. *Drepanosticta septima* sp. nov., female, tip of abdomen, lateral view.
202. *Drepanosticta lymetta* Cowley, female, top of prothorax viewed from the front.
203. *Drepanosticta sundana* Krüger, nymph. (After Lieftinck.)
204. *Drepanosticta septima* sp. nov., female, top of prothorax viewed from the front.
205. *Drepanosticta lymetta* Cowley, female, tip of abdomen, lateral view.
206. *Rhinagrion philippinum* Sélys, head.
207. *Rhinagrion philippinum* Sélys, male, anal appendages, dorsal view.
208. *Rhinagrion philippinum* Sélys, female, tip of abdomen, lateral view.
209. *Rhinagrion philippinum* Sélys, male, anal appendages, lateral view.
210. *Rhinagrion philippinum* Sélys, nymph, mandible in position showing below the serrated border under the eye.
211. *Rhinagrion philippinum* Sélys, nymph, other mandible.
212. *Rhinagrion philippinum* Sélys, nymph, tip of lateral lobe of labium.
213. *Rhinagrion philippinum* Sélys, nymph, labium.
214. *Lestes concinna* Sélys, male, anal appendages, dorsal view.
215. *Rhinagrion philippinum* Sélys, nymph, maxilla.
216. *Rhinagrion philippinum* Sélys, nymph.
217. *Lestes rectangularis* Say, nymph (American), lateral lobe of labium.
218. *Lestes concinna* Sélys, male, anal appendages, lateral view.

PLATE 16

FIG. 219. *Argiocnemis rubeola* Sélys, male, anal appendages, dorsal view.
220. *Argiocnemis rubeola* Sélys, male, anal appendgaes, lateral view.
221. *Pseudagrion pilidorsum* Brauer, male, anal appendages, dorsal view.

222. *Pseudagrion pilidorsum* Brauer, male, anal appendages, lateral view.
223. *Pseudagrion crocops* Sélys, male, anal appendages, dorsal view. (After Ris.)
224. *Pseudagrion crocops* Sélys, male, anal appendages, lateral view. (After Ris.)
225. *Pseudagrion evanidum* sp. nov., male, anal appendages, dorsal view.
226. *Pseudagrion evanidum* sp. nov., male, anal appendages, lateral view.
227. *Pseudagrion microcephalum* Rambur, male, anal appendages, dorsal view.
228. *Pseudagrion microcephalum* Rambur, male, anal appendages, lateral view.
229. *Pseudagrion azureum* sp. nov., male, anal appendages, dorsal view.
230. *Pseudagrion azureum* sp. nov., male, anal appendages, lateral view.
231. *Pseudagrion flavifrons* sp. nov., male, type, anal appendages, dorsal view.
232. *Pseudagrion flavifrons* sp. nov., male, type, anal appendages, lateral view.
233. *Pseudagrion flavifrons* sp. nov., male, variant, anal appendages, dorsal view.
234. *Pseudagrion flavifrons* sp. nov., male, variant, anal appendages, lateral view.
235. *Ischnura elegans* Lind., male, anal appendages, dorsal view.
236. *Ischnura elegans* Lind., male, anal appendages, lateral view.
237. *Ischnura senegalensis* Rambur, male, anal appendages, dorsal view.
238. *Ischnura senegalensis* Rambur, male, anal appendages, lateral view.

PLATE 17

FIG. 239. *Cœnagrion pendulum* sp. nov., color pattern, lateral view.
240. *Moroagrion danielli* sp. nov., male, anal appendages, dorsal view.
241. *Moroagrion danielli* sp. nov., male, anal appendages, lateral view.
242. *Cœnagrion pendulum* sp. nov., male, anal appendages, dorsal view.
243. *Cœnagrion pendulum* sp. nov., male, anal appendages, lateral view.
244. *Caconeura integra* Sélys, male, anal appendages, dorsal view.
245. *Caconeura integra* Sélys, male, anal appendages, lateral view.
246. *Cœnagrion pendulum* sp. nov., head.
247. *Ceriagrion coromandelianum* Fabr., male, anal appendages, dorsal view.
248. *Ceriagrion coromandelianum* Fabr., male, anal appendages, lateral view.
249. *Cœliccia dinoceras* Laidlaw, male, anal appendages, dorsal view.
250. *Cœliccia dinoceras* Laidlaw, male, anal appendages, lateral view.
251. *Cœliccia dinoceras* Laidlaw, male, top of prothorax viewed from the front.

PLATE 18

FIG. 252. *Pericnemis cantuga* sp. nov., male, anal appendages, dorsal view.
253. *Pericnemis cantuga* sp. nov., male, anal appendages, lateral view.
254. *Pericnemis incallida* sp. nov., male, anal appendages, dorsal view.
255. *Pericnemis incallida* sp. nov., male, anal appendages, lateral view.
256. *Pericnemis mcgregori* sp. nov., male, anal appendages, dorsal view.
257. *Pericnemis mcgregori* sp. nov., male, anal appendages, lateral view.
258. *Pericnemis lestoides* Brauer, male, anal appendages, dorsal view.
259. *Pericnemis lestoides* Brauer, male, anal appendages, lateral view.
260. *Pericnemis bonita* sp. nov., male, anal appendages, dorsal view.
261. *Pericnemis bonita* sp. nov., male, anal appendages, lateral view.
262. *Pericnemis flavicornis* sp. nov., male, anal appendages, dorsal view.
263. *Pericnemis flavicornis* sp. nov., male, anal appendages, lateral view.
264. *Pericnemis flavicornis* sp. nov., male, top of prothorax viewed from the front.
265. *Agriocnemis femina* Brauer, male, anal appendages, dorsal view.
266. *Agriocnemis femina* Brauer, male, anal appendages, lateral view.
267. *Agriocnemis velaris* Sélys, male, anal appendages, dorsal view.
268. *Agriocnemis velaris* Sélys, male, anal appendages, lateral view.

PLATE 19

FIG. 269. *Teinobasis olivacea* Ris, male, anal appendages, lateral view.
270. *Teinobasis olivacea* Ris, male, anal appendages, dorsal view.
271. *Teinobasis corolla* sp. nov., male, anal appendages, dorsal view.
272. *Teinobasis corolla* sp. nov., male, anal appendages, lateral view.
273. *Teinobasis nigra* Laidlaw, male, anal appendages, lateral view.
274. *Teinobasis nigra* Laidlaw, male, anal appendages, dorsal view.
275. *Teinobasis filum* Brauer, male, anal appendages, dorsal view.
276. *Teinobasis filum* Brauer, male, anal appendages, lateral view.
277. *Teinobasis filamentum* sp. nov., top of prothorax and synthorax, viewed from the side.
278. *Teinobasis dentifer* sp. nov., top of prothorax and synthorax, viewed from the side.
279. *Teinobasis samaritis* Ris, male, anal appendages, lateral view.
280. *Teinobasis samaritis* Ris, male, anal appendages, dorsal view.
281. *Teinobasis strigosa* sp. nov., male, anal appendages, dorsal view.
282. *Teinobasis strigosa* sp. nov., male, anal appendages, lateral view.
283. *Teinobasis recurva* Sélys, male, anal appendages, lateral view.
284. *Teinobasis recurva* Sélys, male, anal appendages, dorsal view.
285. *Teinobasis filamentum* sp. nov., male, anal appendages, dorsal view.
286. *Teinobasis filamentum* sp. nov., male, anal appendages, lateral view.
287. *Teinobasis nigra* Laidlaw, head.
288. *Teinobasis corolla* sp. nov., head.
289. *Teinobasis olivacea* Ris, head.

PLATE 20

FIG. 290. *Cyrano unicolor* Sélys, forewing.
291. *Rhinagrion philippinum* Sélys, forewing.

292. *Pseudagrion evanidum* sp. nov., forewing.
293. *Pseudagrion evanidum* sp. nov., hind wing.
294. *Caconeura integra* Sélys, forewing.
295. *Argiocnemis rubeola* Sélys, hind wing.
296. *Moroagrion danielli* sp. nov., forewing.
297. *Moroagrion danielli* sp. nov., hind wing.

PLATE 21

FIG. 298. *Teinobasis filamentum* sp. nov., hind wing.
299. *Teinobasis dentifer* sp. nov., hind wing.
300. *Cœnagrion pendulum* sp. nov., forewing.
301. *Cœnagrion pendulum* sp. nov., hind wing.
302. *Agriocnemis femina* Brauer, hind wing.
303. *Pericnemis mcgregori* sp. nov., hind wing.
304. *Pericnemis flavicornis* sp. nov., hind wing.

PLATE 22

FIG. 305. *Pericnemis incallida* sp. nov., hind wing.
306. *Pericnemis bonita* sp. nov., hind wing.
307. *Pericnemis cantuga* sp. nov., hind wing.
308. *Teinobasis olivacea* Ris, nodal area of wing.
309. *Teinobasis nigra* Laidlaw, nodal area of wing.
310. *Drepanosticta lymetta* Cowley, nodal area of wing.
311. *Pericnemis lestoides* Brauer, nodal area of wing.

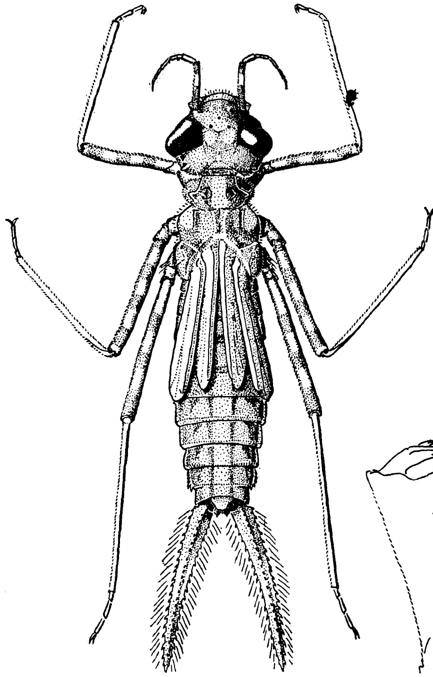
TEXT FIGURES

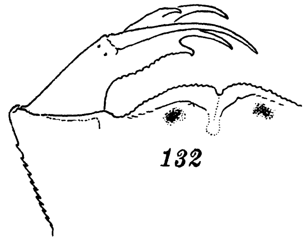
FIG. 3. Venational characters of odonate wings. *1*, Principal veins and their connections; *2*, *Cordulegaster sayi*, wings; *3*, gomphine wing base, male; *4*, libelluline wing base; *5*, arculus and its sectors (M_{1-3}, M_4); *6*, *Cyanocharis valga*, forewing; *7*, *Caliphæa consimilis*, part of wing base; *8*, *Telebasis salva*, forewing; *9*, *Telebasis salva*, part of wing base; *10*, *Anomalagrion hastatum*, stigma, female with brace vein *x*.

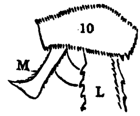
ABBREVIATIONS

A, Anal vein; *AC*, anal crossing; *Al*, or *al*, anal loop; *an*, antenodal crossveins; *ap pl*, apical planate; *ar*, arculus; *b*, basal subcostal crossvein; *br*, bridge; *Bs*, midbasal space, space before the arculus; *brs*, basal radial space; *C*, costa; *Cu*, cubitus; *g*, gaff (fused portion of veins Cu and A_1); *h*, hypertriangular space; *M*, media; *m*, membranule, bordering the 3-celled anal triangle of male hind wing; *ma*, medioanal link; *mf*, middle fork; *mpl*, median planate; *mr*, midrib (bisector of anal loop); *n*, nodus; *o*, oblique vein, *p*, patella; *q*, quadrangle; *R*, radius; *rm*, radial sector; *rpl*, radial planate; *s*, subtriangle; *Sc*, subcosta; *sct*, sectors of the arculus; *sn*, subnodus; *sq*, subquadrangle; *st*, stigma; *t*, triangle; *tr pl*, trigonal planate; *u*, point at which petiolation (stalk) of wing base ceases; *x*, brace vein to stigma.

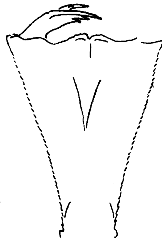
FIG. 4. Variation of wing coloration in *Euphæa refulgens* Sélys. Crosshatching indicates metallic color; linear shading, nonmetallic obfuscation; and clear areas, hyaline.

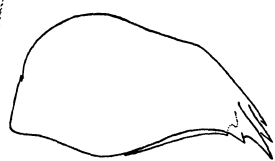

131


132

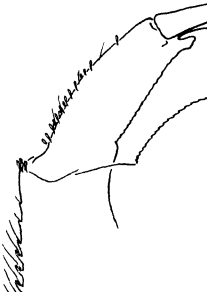


134

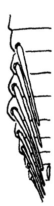

133


135


136


137


138


139

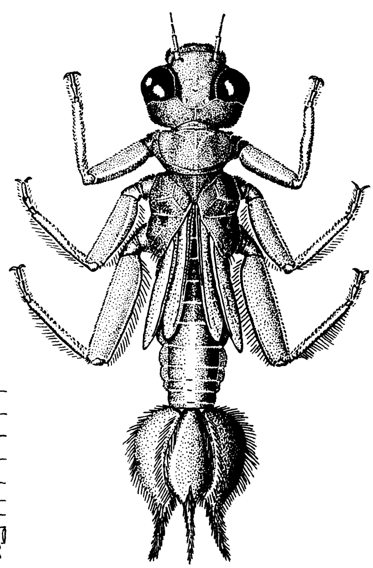

140

PLATE 11.

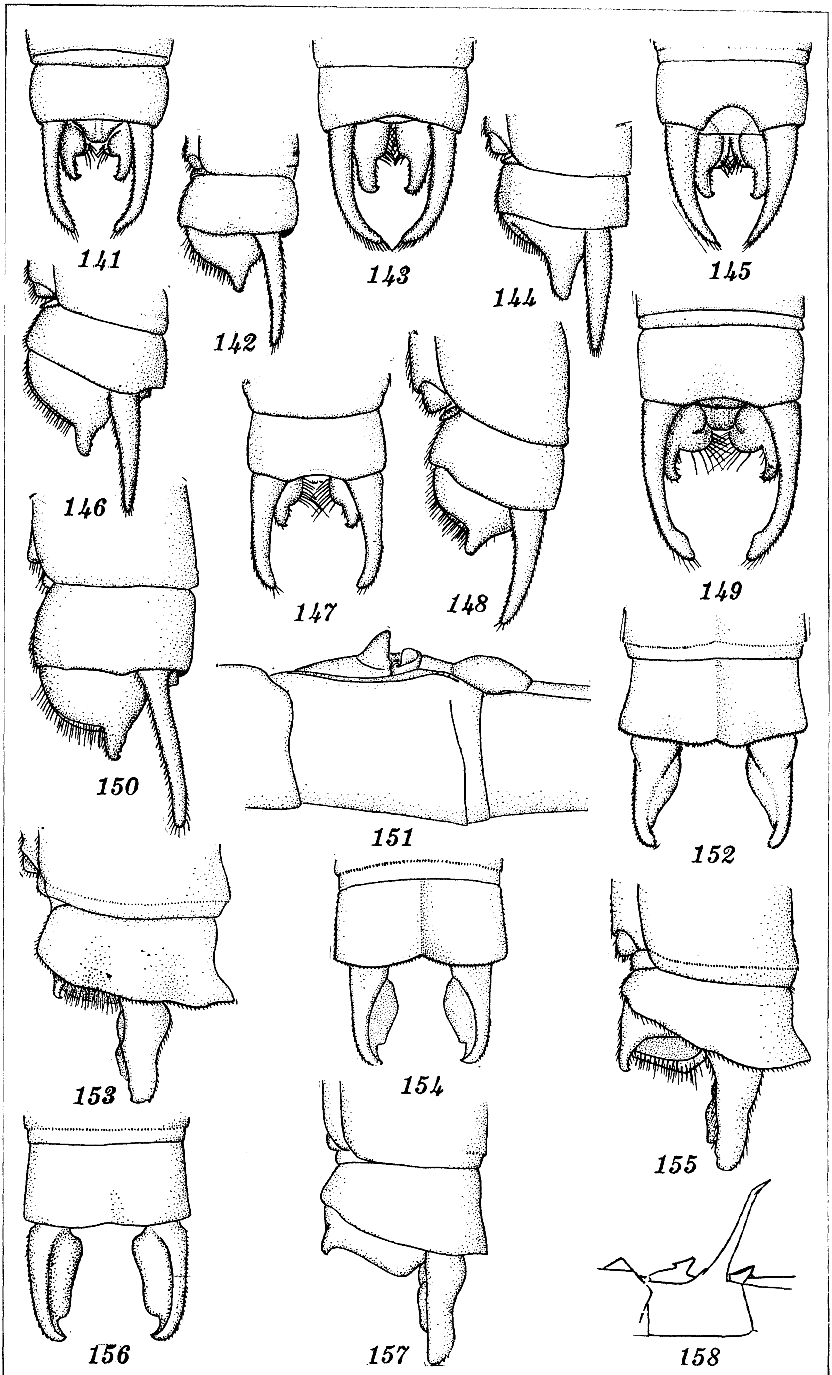

141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158

PLATE 12.

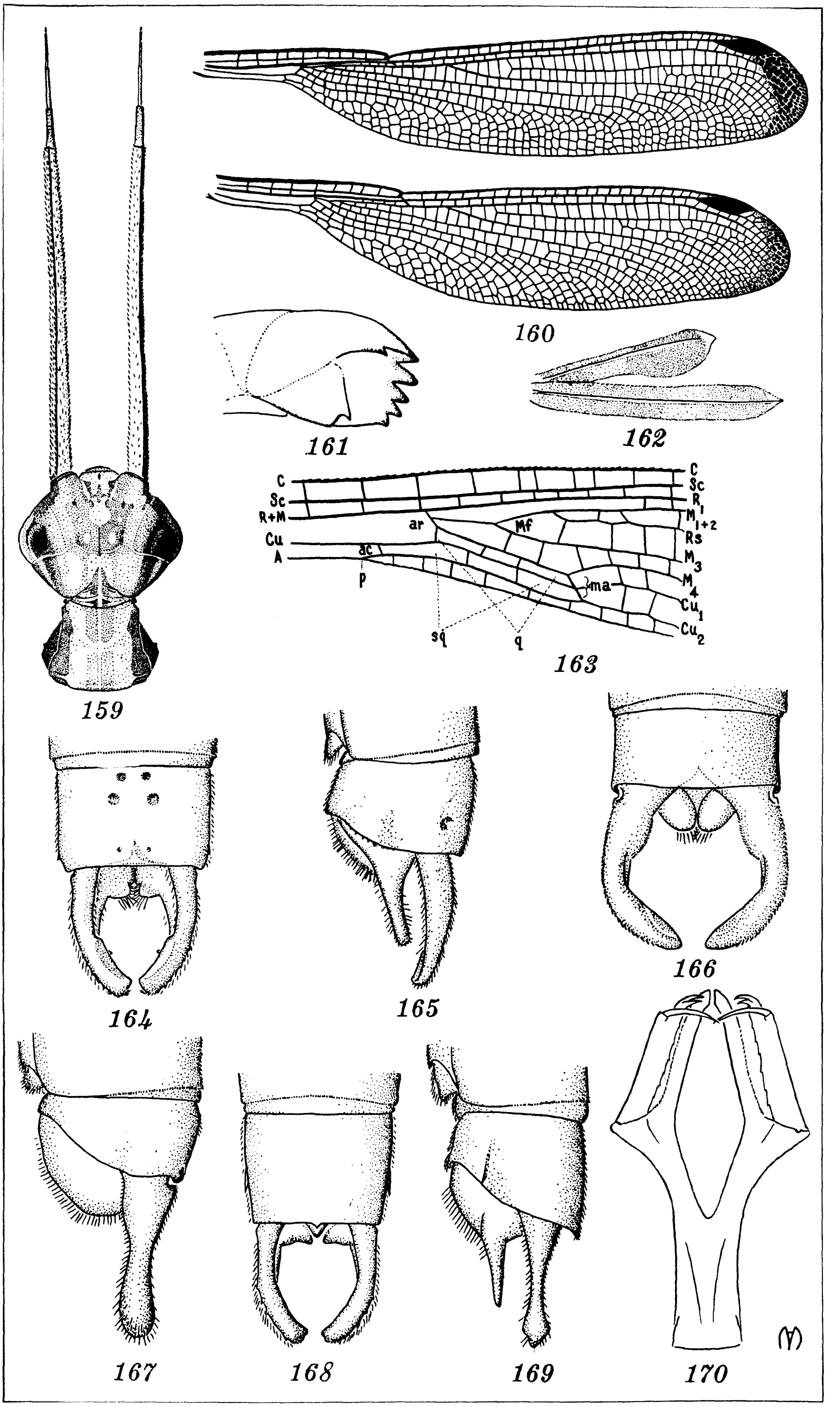

160
161
162
C
Sc
R+M
Cu
A
ar
ac
p
Mf
ma
sq
q
C
Sc
R_1
M_{1+2}
Rs
M_3
M_4
Cu_1
Cu_2
163
159
164
165
166
167
168
169
170

PLATE 13.

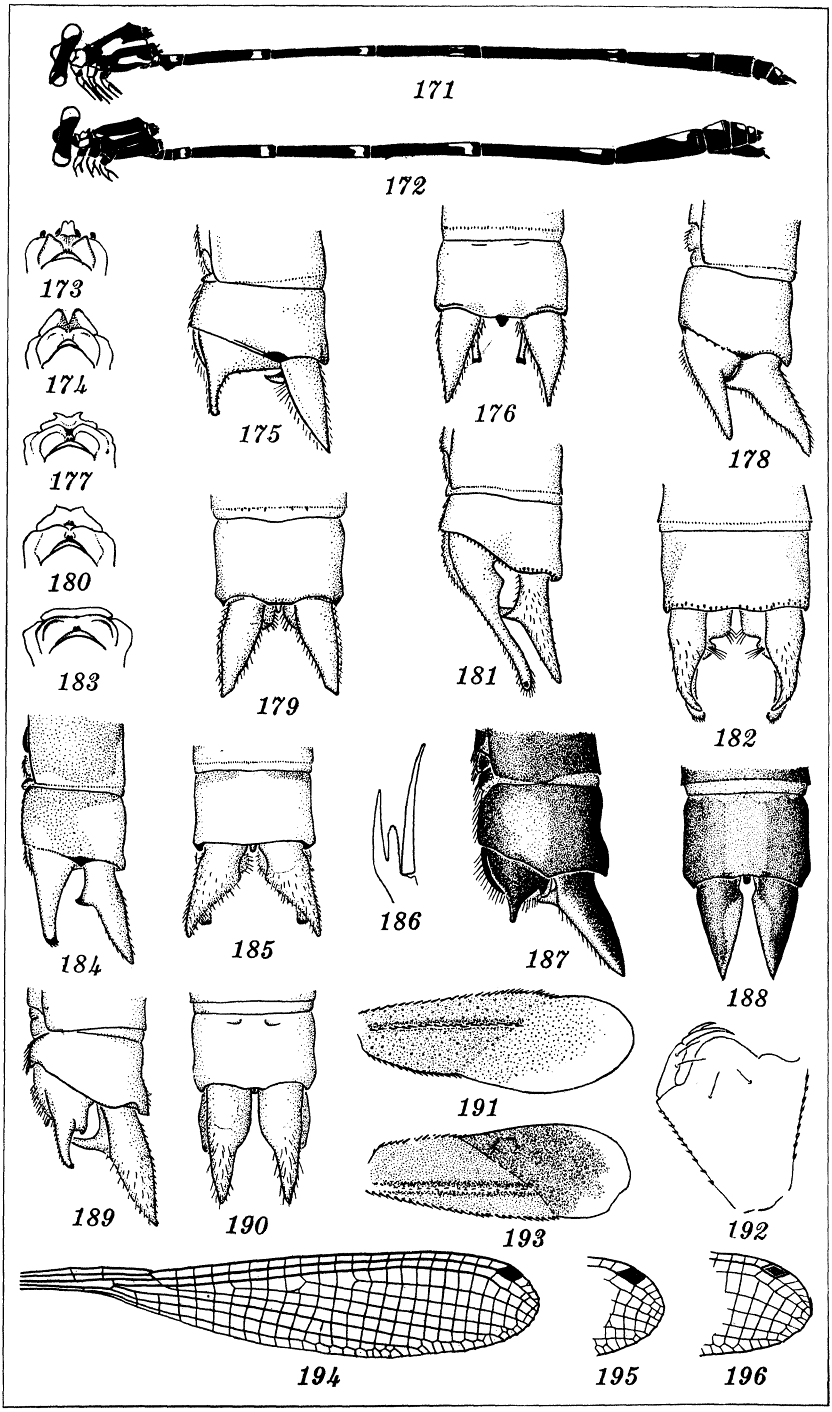

171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196

PLATE 14.

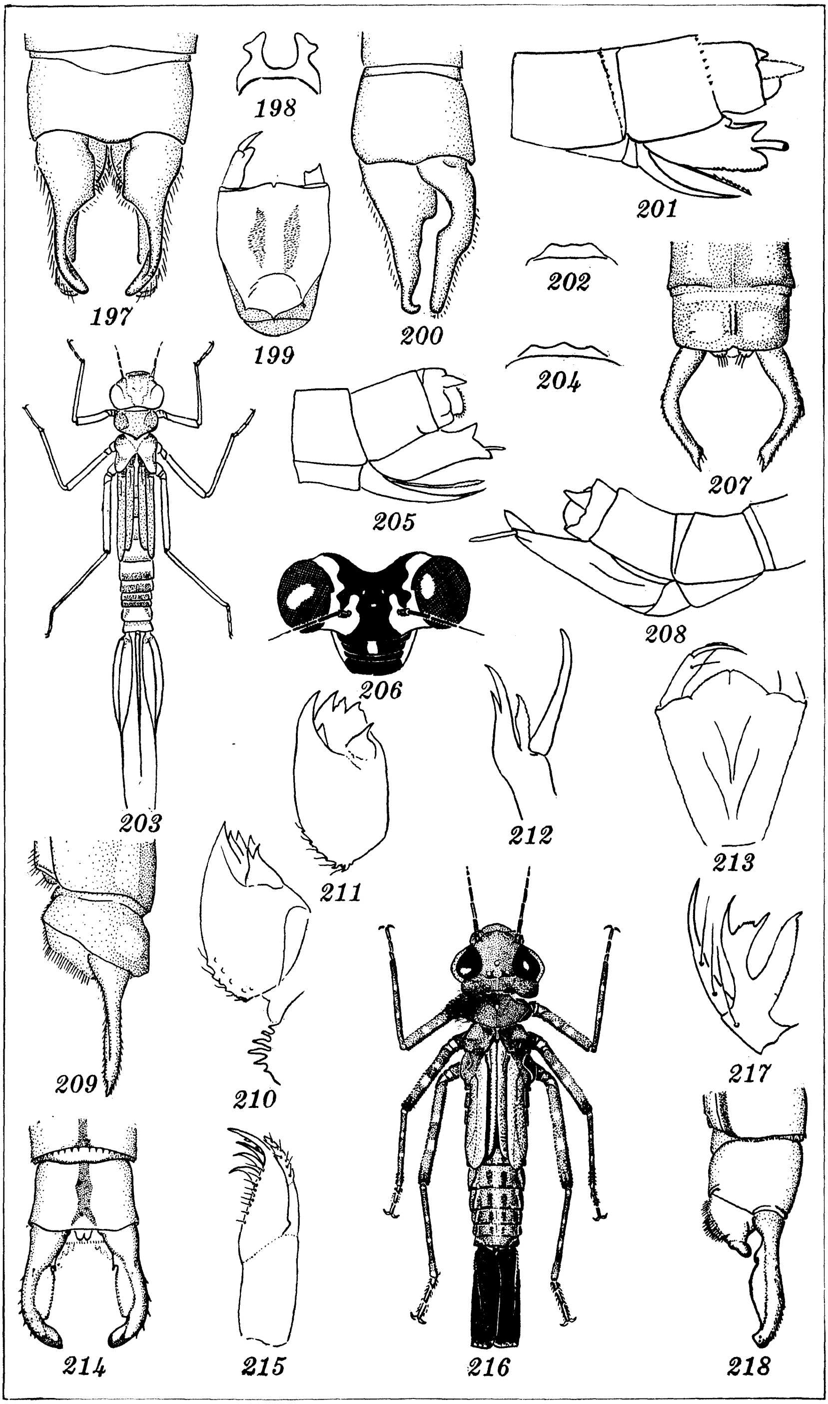

198
201
197
199
200
202
204
207
205
206
208
203
211
212
213
209
210
217
214
215
216
218

PLATE 15.

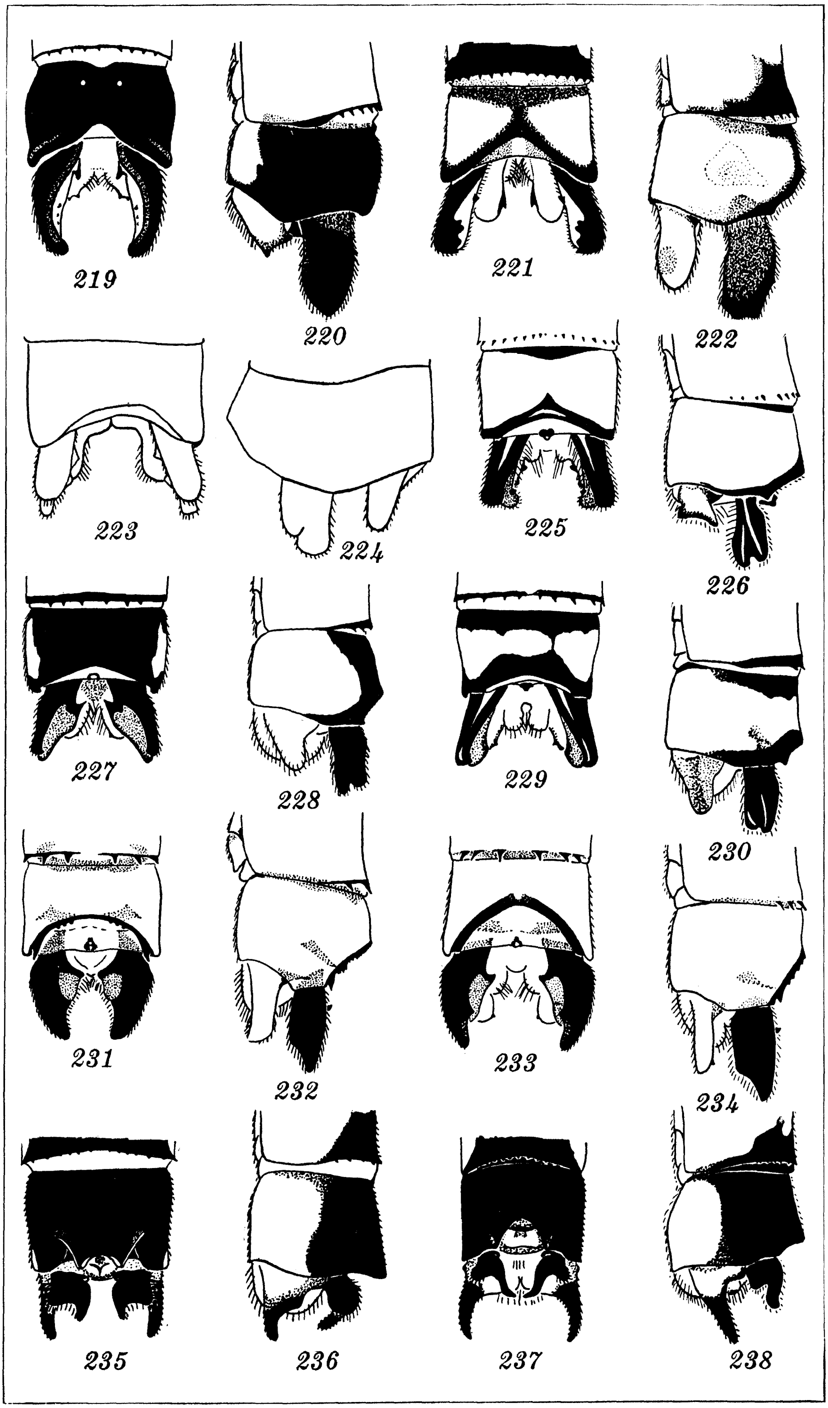

219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238

PLATE 16.

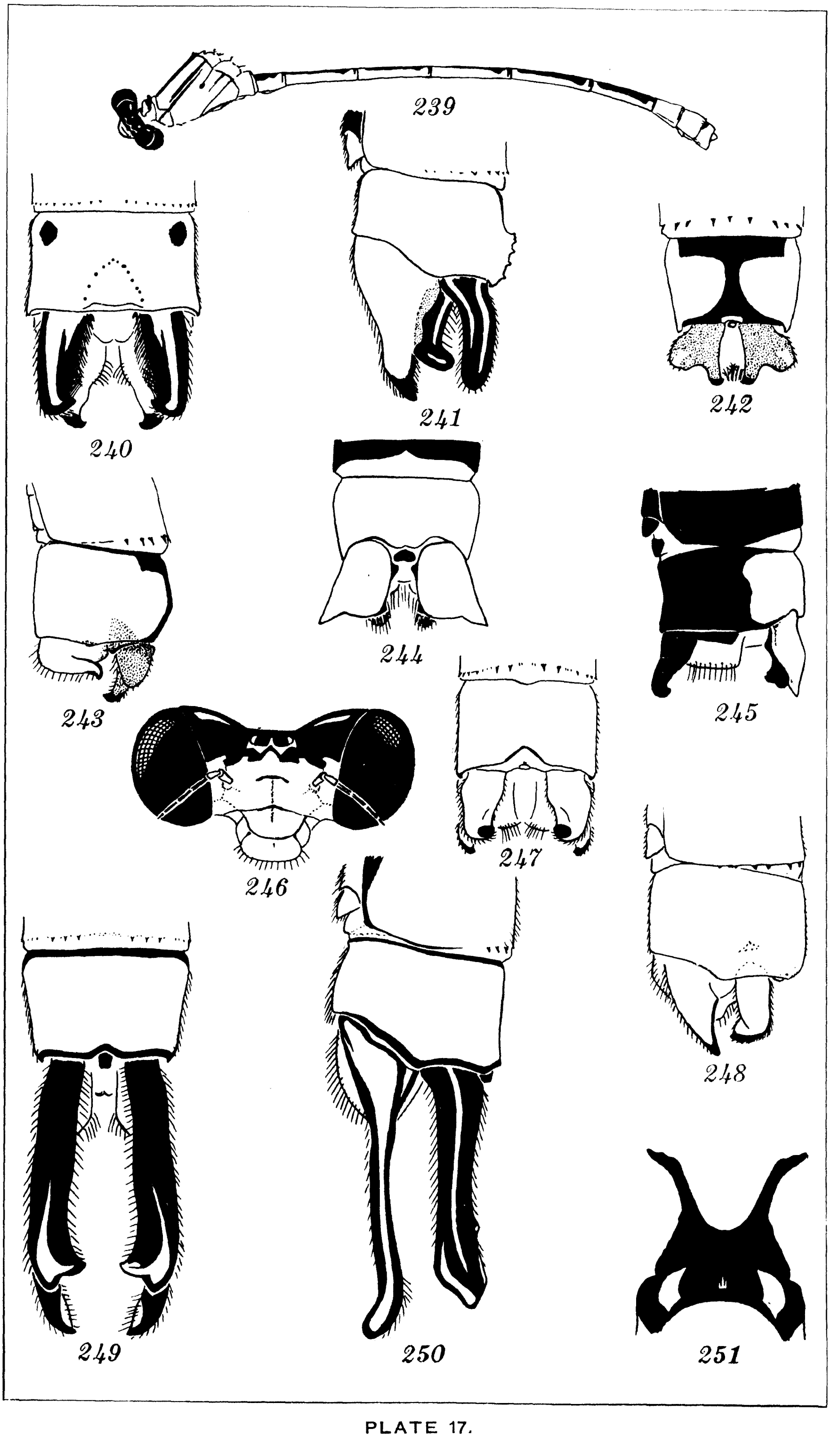


PLATE 17.

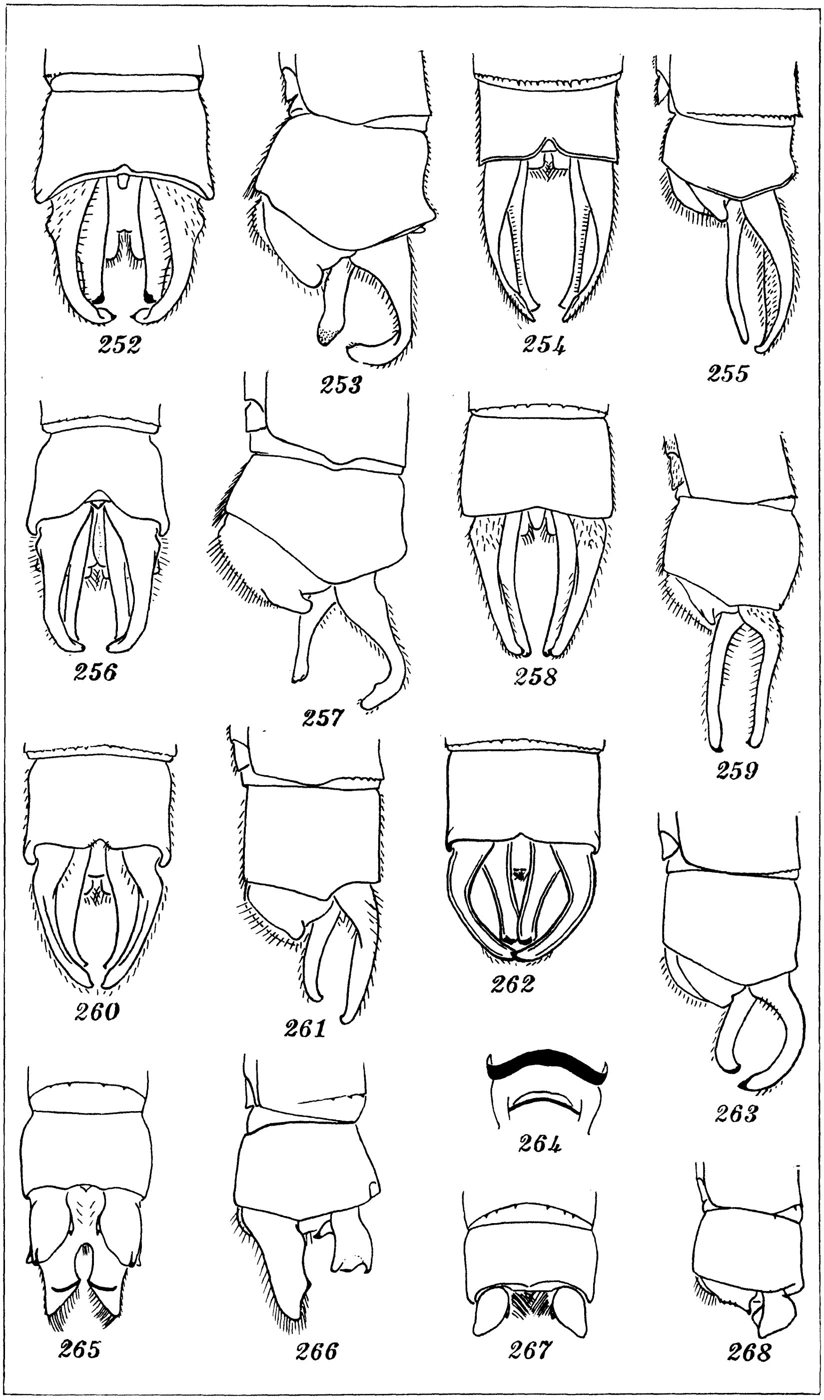

252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268

PLATE 18.

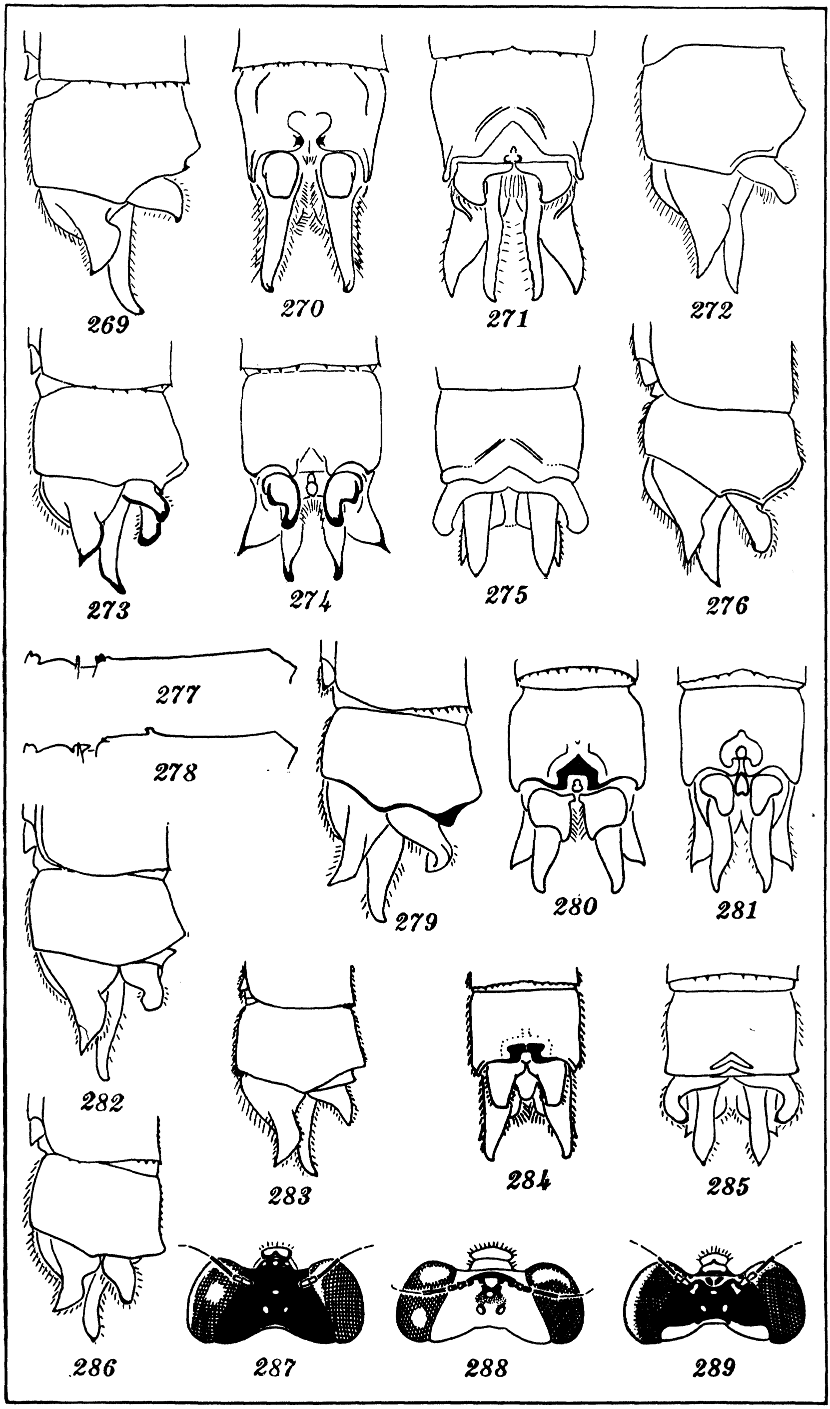
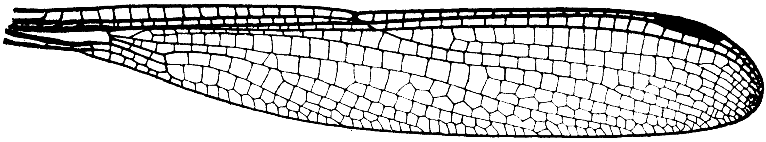
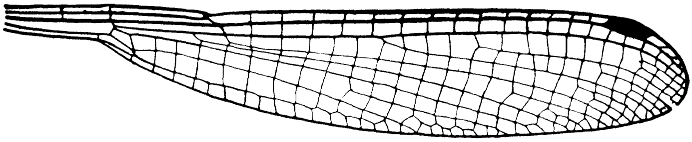

269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289

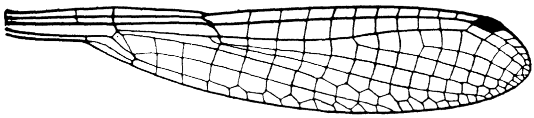
PLATE 19.



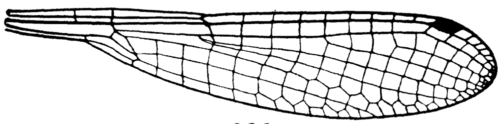
290



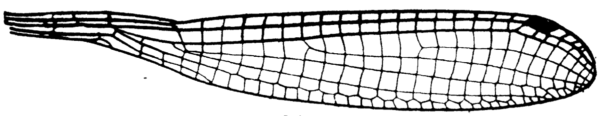
291



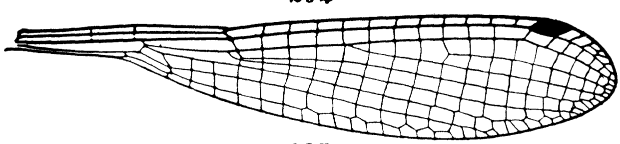
292



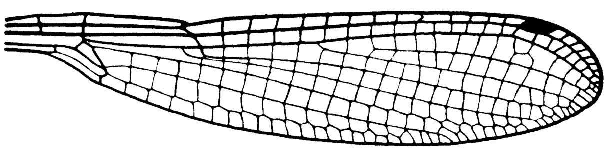
293



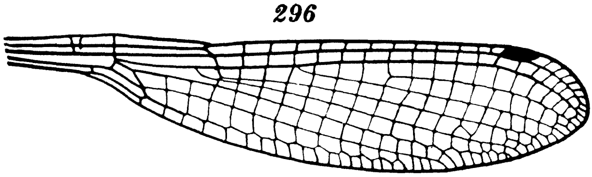
294



295

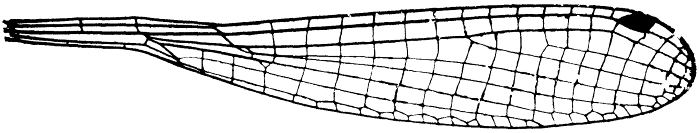


296

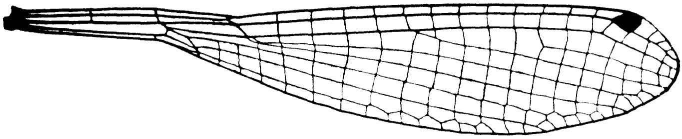


297

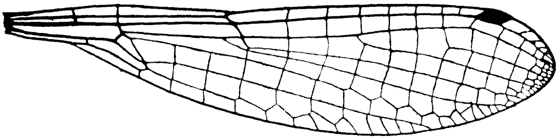
PLATE 20.



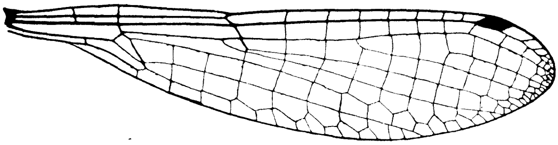
298



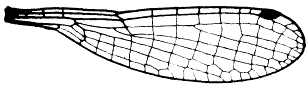
299



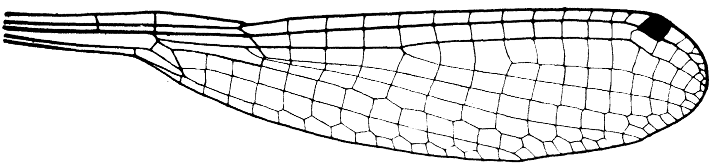
300



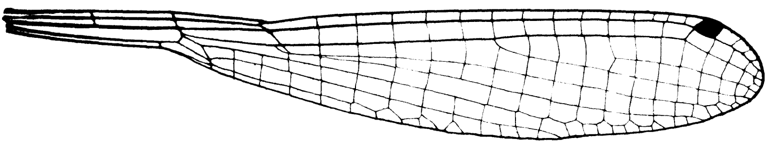
301



302

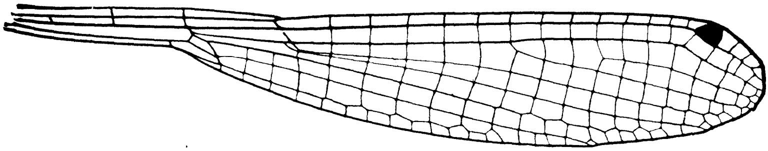


303

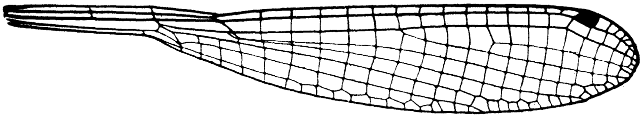


304

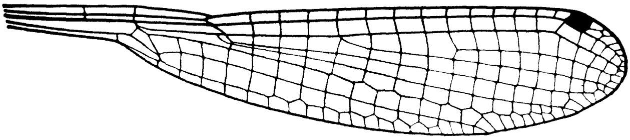
PLATE 21.



305

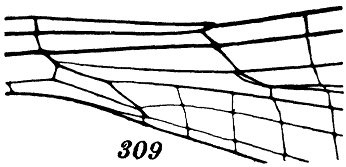


306

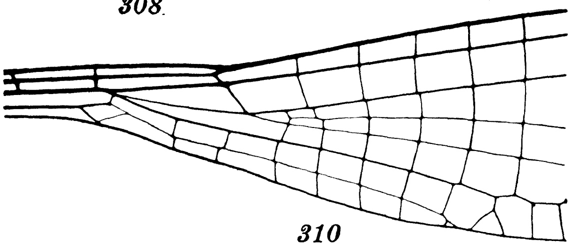


307

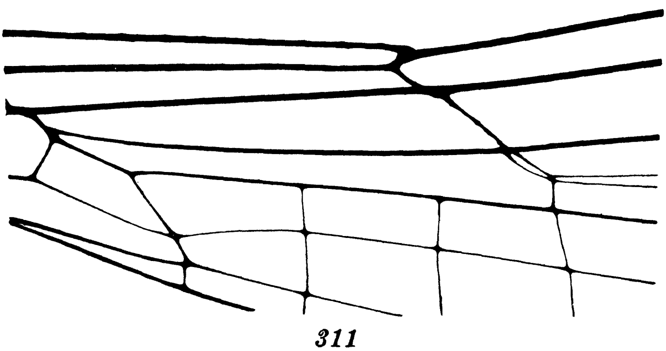
308.



309



310



311

PLATE 22.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 70 DECEMBER, 1939 No. 4

THE PHILIPPINE BLENNIES

By ALBERT W. C. T. HERRE

Of Stanford University, California

FIVE PLATES

Although blennies are common on all Philippine coasts, they are but little or not at all known by most Filipinos. They are abundant in tide pools and on rocky shores throughout, but as they are all small, and do not occur in schools, they are not taken by commercial fishermen. They are therefore seldom seen in the markets, and are not caught by people fishing for their own use. Some Philippine species remain in deeper water, living on the bottom around reefs in coastal waters, and one is pelagic. Certain very small species live commonly in the interstices of coral heads.

The blennies of the world form a very large and natural group that is particularly well developed in the colder regions of the earth. There they attain a much larger size than in the Tropics. Some of those in cold temperate and arctic waters are big enough to be of considerable importance as food fishes. Blennies are mainly shore and shallow-water forms, but also include pelagic and deep-water species. The ventral fins consist of 1 spine and 1 to 3 rays; they are always jugular when present, but may be reduced to mere threads, or may even be absent. The body is usually elongate, cylindrical, and naked, but scales may be present. The teeth may be fixed in the jaws, or may be movable and merely set in the gums; canines are often present in the lower jaw, and some genera have them in both the upper and lower jaws. No molars occur in any Philippine genera. There

may be one, two, or three dorsal fins, occupying most or all of the back from the nape to the caudal base; the dorsal may be composed entirely of spines, or of spines and rays, or spines may be lacking. The caudal is nearly always present, and may be distinct from the dorsal and anal, or may be confluent with them. The anal fin may have a moderate or large number of rays.

There are 50 species of blennies in Philippine waters and in the adjacent Sea of Celebes. They are distributed among 4 families and 13 genera. With one exception they are all rather small, and with two exceptions are all shore or reef dwellers. Our longest blenny is a pelagic species. All are found in salt water except one small species found only in Lake Bombon. Most blennies are carnivorous, but the commonest Philippine blennies are vegetarian, feeding on algæ. As a rule blennies lay eggs, although some species are viviparous.

The common blennies of Philippine seacoasts are among the most active and agile of all fishes. Their acrobatic feats on exposed rocks at low tide rival or even surpass those of *Periophthalmus*, the famed talimosak or mud skipper, and are equally surprising. Their popular names of rock skipper or rock springer are therefore exceedingly apt.

We may divide the Philippine blennies among 4 families, the Clinidæ, the Bleniidæ proper, the Xiphasiidæ, and the Congrogadidæ.

Key to the families of Philippine blennies.

*a*¹. Body covered with scales; spinous dorsal with hard sharp spines, much longer than soft dorsal........ CLINIDÆ.

*a*². No hard sharp spines.

  *b*¹. Spinous and soft-rayed parts of dorsal subequal, caudal free or more or less united with dorsal; dorsal, anal, and caudal confluent in one genus. Body naked, not eellike........ BLENNIIDÆ.

  *b*². Dorsal very long, entirely composed of soft rays, or with only a few soft spines anteriorly; caudal, dorsal, and anal confluent.

    *c*¹. Body naked, eellike, dorsal origin over or before eye, all fin rays flexible; tail four to six times as long as head and trunk together. XIPHASIIDÆ.

    *c*². No ventrals; body covered with very small scales; lips strongly developed; dorsal origin behind head; no dorsal spines; tail less than twice as long as head and trunk together.... CONGROGADIDÆ.

CLINIDÆ

Small tropical blennies, body nearly always covered with scales. Spinous portion of dorsal fin longer than rayed, soft portion, or all rays converted into spines; in some species dorsal

with two spinous parts and a shorter-rayed portion; anal with one or two spines; ventrals on throat, composed of a spine and three or four simple articulated rays. Gill membranes united, free from isthmus. Jaws with conical or villiform teeth, often teeth on vomer and palatines.

The group is positively represented in Philippine waters by two genera, and a third genus is doubtfully recorded. The species occur on coral reefs, especially in and around coral heads.

Key to the Philippine genera of Clinidæ.

a[1]. Three dorsal fins, the two anterior ones composed of soft spines; anal spines also soft .... *Tripterygion.*

a[2]. Two dorsal fins.

b[1]. First dorsal composed of 3 spines; second dorsal composed of 25 to 30 spines and 3 to 8 rays, all spines hard and sharp; anal with 2 hard sharp spines and 19 to 25 rays .... *Cristiceps.*

b[2]. First dorsal composed of 2 long threadlike spines; second dorsal, 45 to 50; anal with more than 50 rays .... *Paracristiceps.*

Genus TRIPTERYGION Risso

Tripterygion RISSO, Hist. 3 (1826) 241.
Enneapterygius RÜPPELL, Neue Wirbelt. Fische (1835) 2.
Tripterygium GÜNTHER, Cat. Fishes 3 (1861) 276.

Body not elongate, covered with small or medium-sized scales. Dorsal fins 3, first dorsal fin composed of 3, second of 10 to 24 soft spines, third of 7 to 14 rays; anal with 1 or 2 soft spines and 14 to 22 rays. Ventrals jugular, composed of 2 soft rays. Branchiostegals 6; pseudobranchiæ present.

Small fishes of tropical reefs and tide pools, commonly living in the interstices of coral heads, and therefore difficult to observe or collect. Also abundant about New Zealand, in the Mediterranean, and in other warm temperate waters. Four species are recorded from Philippine waters.

Key to the Philippine species of Tripterygion.

a[1]. Scales 47 to 50; dorsals III, XIII, 9 or 10; anal I, 18 to 20. 1. *T. trigloides.*

a[2]. Scales 30 to 33; dorsals III, X or XI, 7 to 9; anal I, 14 to 16.

b[1]. Pectoral with 7 or 8 undivided and 8 divided rays; dorsals III, X or XI, 9; anal I, 14 or 15 .... 2. *T. callionymi.*

b[2]. Pectoral with 6 undivided lower rays.

c[1]. Dorsals III, XI, 9; anal I, 15 or 16; divided pectoral rays 9; caudal faintly barred, anal clear with black spots .... 3. *T. philippinum.*

c[2]. Dorsals III, X or XI, 7 or 8; anal I, 14 or 15; divided pectoral rays 7 or 8; caudal and anal black .... 4. *T. punctulatum.*

1. **TRIPTERYGION TRIGLOIDES** Bleeker.

Tripterygion trigloides BLEEKER, Nat. Tijds. Ned. Ind. 15 (1858) 234.
Tripterygion trigloides M. WEBER, Fische Siboga Exped. (1913) 545, fig. 115; HERRE, Fishes 1931 Philip. Exped. (1934) 95.

Dorsals III, XIII or XIV, 9 or 10; anal I, 18 to 20. Head and nape naked, with 47 to 50 scales in a longitudinal series, plus 1 or 2 on caudal base, scales more or less irregular; tubulated scales in lateral line 18 to 22, stopping beneath hind end of the second dorsal or front of third dorsal.

Depth 5, head 3.2 to 3.4, caudal 5, pectoral 3.8 to 3.9 times in length. Head very large, broad, shaped like that of *Trigla*, anterior profile convexly rounded with protruding lips and large mouth extending beneath middle of eye. Snout 2.75 to 2.85, eye 3.3 to 3.66 times in head. Upper 10 rays of pectoral divided, lower 6 undivided.

Alcoholic specimens reddish brown to pale tan, with irregular spots and flecks of silvery white scattered over sides; over back and down sides 5 double crossbars, varying from dark red-brown to blackish; top and sides of head thickly sprinkled with black dots, upper lip dark purple to blackish; dorsals and caudal barred with dusky bands, or dorsals largely covered with dark red-brown specks; anal varying from clear, with a few red-brown spots or bands, to entirely dusky, difference probably being sexual. Iris golden red.

I collected 5 examples, 22 to 28 mm long, at Dumaguete, Oriental Negros Province, and 2 very fine specimens, 34 and 35 mm long, at Lembeh Strait, Celebes. Weber had 1 specimen, 35 mm long, from Tiur, a small East Indian island, and Bleeker had 1 specimen, 38 mm long, from Billiton. In life this blenny is very handsome, largely rose-red, with iridescent spots and flecks of pearly blue.

2. **TRIPTERYGION CALLIONYMI** M. Weber.

Tripterygion callionymi M. WEBER, Notes Leiden Museum 31 (1909) 147; Fische Siboga Exped. (1913) 546, figs. 116 and 117; HERRE, Fishes 1931 Philip. Exped. (1934) 95.

Dorsals III, X or XI, 9; anal I, 14 or 15; pectoral with 8 divided and 7 or 8 undivided rays. Scales 31 to 33, plus 1 or 2 on caudal base; 3 scales above, and 6 below lateral line. Weber's specimens had 12 spines in the second division of the dorsal.

Depth 5, head 4.5 times in length. The peculiar concave, sharp-pointed snout equals the large prominent eye, $3\frac{1}{3}$ times in head. Scales extending forward to nape; lateral line extend-

ing back on 12 to 14 scales to a point under middle of second dorsal; dropping down two scale rows, it is represented from there to the caudal base by a semicircular pit on the hind margin of 17 to 19 scales. Second dorsal highest, caudal truncate.

Yellowish, thickly sprinkled with large and small black dots, between silvery spots and lines. Other specimens with 6 double crossbars, vaguely defined on back, upper half, and on caudal base, and a row of spots at anal base; very poorly defined cross-bands on dorsal, a row of dots on anal. Some specimens have the markings much like those of *Enneapterigius fasciatum* (M. Weber) but with the entirely different snout and physiognomy of *E. callionymi.*

I collected Philippine examples as follows, from 16 to 26 mm long: Culion 2; Dumaguete 5; Sitankai 1. Weber obtained 9 specimens at various stations from Celebes to Lombok.

3. **TRIPTERYGION PHILIPPINUM Peters.**

Tripterygium philippinum PETERS, Monatsber. Akad. Wiss. Berlin (1868) 269.

Enneapterygius philippinus JORDAN and RICHARDSON, Bull. Bur. Fish. 27 (1908) 283.

Dorsals III, XI, 9; anal I, 15 or 16; scales 30 to 32 in a lateral series, plus 1 or 2 on caudal base; 12 tubulated scales in lateral line, 18 with pores in hind margin along middle of side back to caudal base.

Depth 5 to 5.75, head 3.7 to 3.8, caudal 5.75, pectoral 2.75 to 3.25 times in length; eye 3 to 3.2, snout about 3.4, least depth of caudal peduncle 3 times in head. Lower 6 pectoral rays undivided, upper 9 divided. Nasal tentacles very short; no orbital tentacles. Small snout, pointed as in other members of the genus.

Rose-red in life, becoming clear brown or fading to pale yellow in alcohol, head more or less thickly sprinkled with dark or blackish specks. Below pectoral base a large silver spot, a pair of smaller silver spots before ventral base; dorsal more or less spotted with dusky, pectoral with 4 rows of black specks. At caudal base a silvery or red blotch; caudal fin faintly barred with dark spots.

Peters's description was made from 2 specimens, each 25 mm long, from a coral reef near Paracale, Camarines Norte Province. Jordan and Richardson described 2 examples, 18 and 23 mm long, collected by R. C. McGregor at Calayan Island, one of the Babuyanes, north of Luzon. These are in the Stanford University Museum, and have been examined by me.

4. TRIPTERYGION PUNCTULATUM (Herre).

Enneapterygius punctulatus HERRE, Fishes Crane Pacific Exped. F. Mus. Nat. Hist. Zoölogy 21 (1936) 397, fig. 37.

Three specimens of this rare little fish were taken from a tide pool at Nasugbu, Batangas Province, 16 to 21 mm long.

Dorsals III, X or XI, 7 or 8; anal I, 14 or 15; scales 32, plus 2 on caudal base; 13 to 15 tubulated scales in upper part of lateral line, 3 above and 6 below it; along middle of side 16 to 18 scales with pores on hind margin. All dorsal and anal rays simple, except last one of each.

Depth 5.25, head 3.7, pectoral 3.5 to 3.6, caudal 4.2 times in length. Eye 2.85, snout 2.9 to 3, depth of caudal peduncle 3.5, height of second dorsal 1.9 times in head. Head broad, resembling that of a *Trigla,* with large prominent eyes set very close together, and small, pointed snout. Orbital tentacle minute. First dorsal very low; large pectoral extending nearly to hind end of second dorsal; caudal rounded. Uppermost 7 or 8 pectoral rays divided, lower 6 undivided.

Alcoholic specimens whitish, heavily shaded with black dots that may form vague crossbands. Dots largest and most numerous on lower half and breast and under head, those on underside often ocellated. Caudal and anal blackish or black; second dorsal with a dusky margin, a black bar sometimes present at base of second and third dorsals.

Previously known only from specimens I obtained in the New Hebrides.

Genus CRISTICEPS Cuvier and Valenciennes

Cristiceps CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 194–402.

Body of moderate length, covered with small or rudimentary scales. Snout short, mouth of medium size, lower jaw often prominent. Jaw teeth small, in bands; vomerine and palatine teeth present. Dorsals 2, first dorsal on head, composed of 3 sharp spines; second dorsal long, composed of 25 to 30 sharp spines and 3 to 8 rays; anal with 2 hard sharp spines and 19 to 25 rays; dorsal rays may be united with caudal; ventrals jugular, composed of 1 spine and 2 or 3 rays. Tentacles present on eye and nostril. Gill opening wide; branchiostegals 6. The species are viviparous.

But 1 species is known from the Philippines. Small fishes, species few, occurring on reefs in the East Indies, in rivers and

along the shores of Australia and Tasmania, and in the Mediterranean.

CRISTICEPS XANTHOSOMA (Bleeker).

Clinus xanthosoma BLEEKER, Nat. Tijds. Ned. Ind. 13 (1857) 340.
Cristiceps xanthosoma GÜNTHER, Cat. Fishes 3 (1861) 273; HERRE, Philip. Journ. Sci. 59 (1936) 371.

First dorsal III, second dorsal XXVII, 4; anal II, 19; about 50 tubules in lateral line; scales very small, not deciduous, about 110 above and 100 below lateral line.

Depth 4, head 3.48, caudal and pectoral each 5.55, ventral 6.1 times in length; eye 4.16, snout 5, maxillary 2.7, interorbital 7 times in head.

Body deep, laterally compressed, ventral profile strongly convex; head moderately arched from dorsal origin to tip of projecting lower jaw; eyes high up, lateral, with a fimbriate tentacle on margin of each, half or more than half eye in length; a small simple nasal tentacle; mouth strongly oblique, maxillary extending beneath front margin of pupil; small teeth forming a band of 5 rows in front, dwindling to a single row posteriorly, alike in both jaws; minute teeth on vomer and palatines. Dorsal spines all hard and sharp-pointed, with only 4 divided rays at posterior end of dorsal fin; anal spines likewise hard and sharp. Vertical fins low, first dorsal spine 2.5 in head; second dorsal uniform in height, 3.18 in head; first dorsal ray equal to first dorsal spine; anal rays of uniform height, 2.9 in head.

Alcoholic specimens uniform yellow, all fins as well as body.

This handsome blenny, previously unknown in the Philippines, is represented by a specimen 61 mm long, from a reef at Paraoir, La Union Province, Luzon. Hitherto known only from Java, from specimens described by Bleeker in 1857.

My specimen is a female, containing very many eyed embryos.

Genus PARACRISTICEPS novum

This genus is separated from *Cristiceps* by the differences in the dorsal and anal fins. First dorsal composed of 2 greatly elongated and threadlike spines; number of dorsal and anal rays or spines greatly increased; second dorsal with more than 45 rays, anal with more than 50. Dorsal and anal fins singularly shaped, their form strongly divergent from that of *Cristiceps*. Anterior dorsal rays very high, forming a triangle, followed by very short rays connecting it with a high posterior part. Anal of similar shape. Caudal free.

A single species, supposed to occur in the Philippines.

Type: *Paracristiceps filifer* (Steindachner).

PARACRISTICEPS FILIFER (Steindachner).

Cristiceps filifer STEINDACHNER, Archiv. Zool. 3 (1864) 199.

Dorsal II, 49; anal 54; caudal 16; ventral I, 3. Scales in lateral line about 60, 12 in transverse series.

Height equal to length of head, 8 times in total length; tentacles none. Snout rounded, cleft of mouth under eye. Jaws with a row of fine pointed teeth, vomer with velvety teeth. Ctenoid scales very deciduous. Over hind part of head 2 dorsal spines of extraordinary length, their height one-third of total length. Opposite these on the throat is the ventral, whose outer ray is similar, its length equal to half the total length. Second dorsal and anal beginning opposite each other, at commencement of second third of total length. First 15 dorsal rays forming a triangle, higher than body; after these, 15 short and hardly noticeable rays, which connect the high forward part with the hinder part of 19 rays only half as high. Anal similar in form; high forward part containing 20, the much shorter middle part 12, hind part 22 rays. Dorsal and anal ending shortly before caudal. Lancet-shaped caudal fin longer than head; caudal peduncle very slender.

Yellow, back showing numerous fine black dots.

The Vienna Museum had 2 specimens, in very bad condition, without definite locality other than the Philippines. Doctor Steindachner also found a colored painting of this species in the Museum, made from a specimen at Bombay.

That this fish occurs in the Philippines is very doubtful.

BLENNIIDÆ

As treated here, this family includes all those elongate naked blennies which have the soft spinous and soft-rayed portions of the dorsal more or less subequal, or else have a dorsal composed of 60 or more flexible spines, without rays, and the tail never 4 to 6 times as long as the head and trunk together. Teeth in a single, close-set, comblike series, fixed or movable. Ventrals jugular, with a spine and 2 to 4 rays. Pseudobranchiæ present.

This family includes a large number of fishes living in shallow coastal waters of tropical and temperate regions, nearly all of them small. A few live at considerable depths, and rarely there are fresh-water species. The great majority are egg-laying.

Most of them are carnivorous, but certain genera feed on algæ. Some species are exceedingly active and go about on exposed rocks at low tide in search of food, moving around with the agility of lizards.

Key to the genera of Blenniidæ known from the Philippines and the Sea of Celebes.

a[1]. Spinous and soft rays of dorsal of nearly equal extent, their combined number always less than 50; tips of teeth never arrow-shaped; depth never more than 9 in length.
  b[1]. Teeth fixed in one row in each jaw.
    c[1]. Gill opening wide, extending forward below and free from isthmus; a small posterior canine may be present on each side in both jaws, or in lower jaw only .... 1. *Blennius.*
    c[2]. Gill opening restricted; a pair of stout to very large posterior canines in lower jaw, and a pair of smaller ones in upper jaw.
      d[1]. Dorsal and anal never both confluent with caudal; gill opening a small slit above upper angle of pectoral base.... 2. *Petroscirtes.*
      d[2]. Dorsal and anal both attached to caudal and more or less confluent; gill opening extending downward along pectoral base. 3. *Enchelyurus.*
  b[2]. Teeth small, numerous, movable, set on gums.
    c[1]. A semicircular or oval adhesive disc behind mouth, under lower jaw. 4. *Andamia.*
    c[2]. No adhesive disc behind mouth.
      d[1]. A fringe of small tentacles across nape........ 5. *Cirripectes.*
      d[2]. No fringe of tentacles across nape........ 6. *Salarias.*
a[2]. Dorsal of 60 or more flexible spines, without rays; teeth fixed, in one row, those of lower jaw with arrowlike tips; depth 15 or more in length .... 7. *Lembeichthys.*

Genus BLENNIUS Linnæus

Body deep, oblong, compressed, naked; head large, anterior profile nearly vertical or very steep. Mouth with a single row of slender, curved, close-set fixed teeth in each jaw, with a stout canine on each side below, and usually a pair of smaller canines in upper jaw. Gill openings wide, extending forward below, free from isthmus or forming a broad fold across it. Dorsal fin entire, or somewhat emarginate, with slender flexible spines. Lateral line developed only anteriorly.

A genus with numerous species in warm temperate seas, some occurring in the lakes of northern Italy. Only a few species occur in East Indian and adjacent seas. They are all small and dull-colored. Only one species is known to occur in Philippine waters.

BLENNIUS THYSANIUS Jordan and Seale.

Blennius thysanius JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 47, fig. 19.

Dorsal 25 to 27 (XII or XIII, 12 to 15); anal 15 to 19 (I, 14 to 17 or II, 15 to 17).

Body very deep, compressed, head as deep or deeper than trunk, snout very steeply inclined to nearly vertical; dorsal and anal free from caudal. Depth 3 to 3.6, head 2.9 to 3.2 (by exception, 3.5), caudal 1.7 to 1.8, pectoral 4, ventral 6 times in length; eye 4.5 to 6, snout 2.6 to 3, least depth of caudal peduncle 3.5 to 3.6, pectoral 1.4, ventral 2.15 to 2.25 times in head; narrow interorbital 3.5 times in eye, eye 1.5 to nearly 2 times in snout. Base of anal fin 1.9 to 2 times in length of dorsal base. There is a short, broad, fimbriate tentacle.

Mouth nearly horizontal, maxillary extending beneath middle or posterior rim of eye, or in old males beyond eye; lower jaw with a pair of canines, upper jaw with a posterior pair of smaller canines. The original description gave 2 canines on each side of the lower jaw, and examination of the type, an old male, showed 2 canines on one side only, evidently an abnormality. The dorsal is not notched, or by exception in old males may have a slight depression on the anterior portion or above the twelfth or thirteenth spine. In males the two anal spines have large bulbous tips, as in most species of *Blennius*.

Dark brown in life, with 6 to 8 darker crossbands sometimes present; sides and under parts of head and pectoral base spotted with paler; dorsal with a dark blotch or band on upper part of dorsal anteriorly and rows of spots all over; anal yellowish, with a submarginal dark band, tip of rays white; caudal and pectorals yellow, latter with a brown spot on lower third.

Alcoholic specimens brown, sprinkled with small dark-brown spots and vertical lines; smallest specimens showing traces of 8 dark crossbands on nape and trunk; dorsal pale brown with rows of darker spots which often disappear; a blackish spot may be present between first and second dorsal spines or between third to sixth spines, or a dark-brown band along upper part of first half dozen spines; other fins little changed.

This little blenny occurs abundantly amid the sponges, hydroids, and mollusks covering the surface of harbor buoys left a long time in the water. The blennies crawl about under the luxuriant growth, where they have an abundance of food and complete protection.

Described from 5 specimens, 27 to 40 mm long, from Puerto Princesa, Palawan; 21 specimens, 41 to 52 mm long, from Catbalogan, Samar; and 26 specimens, 25 to 43 mm long, from Darman Passage, off Leyte. The Palawan specimens diverge rather widely from the type, and at first I called them new. A critical study of the type and the above series proved them all to belong to the same species. Jordan and Seale had 2 examples, 63.5 and 73.5 mm, from Cavite. The type is in the United States National Museum, and the cotype in the Stanford Museum.

Genus PETROSCIRTES Rüppell

Petroscirtes RÜPPELL, Atlas Fische (1837) 110.

Body naked, more or less elongate, with a small or medium-sized head which often has tentacles on the eye, and may also have them on the nape and nostrils; more rarely there are tentacles on the opercular and preopercular margins, on the chin, and on the throat. Snout short, or of moderate length, convex or elongate and conical. Mouth often rather small, but may be rather large and extending to hind margin of eye. Teeth fixed, in one row, with a very large curved posterior canine on each side of lower jaw; upper jaw with a pair of similar but much smaller canines. Gill opening reduced to a small slit or a nearly circular aperture above upper angle of pectoral base. Dorsal fin continuous and undivided, but 2 or 3 anterior rays may be elongated and filamentous so that they are semidetached. Dorsal usually ending on caudal peduncle, before caudal fin, but in a few species extending to base of caudal. Ventrals jugular, composed of 2 or 3 rays. Unlike most blennies, the fishes of this genus have an air bladder.

This group contains numerous species in the tropical portions of the Indian and Pacific Oceans, where they replace the genus *Blennius* of temperate regions. The species of *Petroscirtes* are common on coral reefs throughout, but as a rule those in the Philippines live in deeper water than do the blennies of the genus *Salarias*. However, some species do not move off with the receding tide, but remain in shallow rocky pools or stay on exposed rocks until the incoming tide covers them again.

Unlike *Salarias*, they are carnivorous, and certain species leap about on the rocks with great agility in pursuit of their prey. The name *Petroscirtes*, rock springer, was given by Rüppell because of the activities of a species he discovered in the Red Sea.

When one examines preserved material it usually seems impossible for the fish to ever open its mouth wide enough to use

its preposterously large lower canines. Many have speculated about the use of these huge teeth, which contrast so greatly with the rest of the teeth. Examination of living or fresh specimens, however, shows that the mouth has a surprising gape; as the lower jaw drops, the great canines come out of their hiding places and point forward ready for action. If one handles living specimens he very quickly discovers one use of their canines as they sink them into his fingers. More than a century ago Rüppell saw "rock springers" skipping about over the rocks and impaling their prey with their great fangs.

The 15 species described here are by no means all that are found in Philippine waters. No doubt nearly all that are known from the East Indies and Polynesia will ultimately be discovered in the Philippines. The rock springers are, as a group, shy and elusive fishes, swift of movement and able to hide in tiny rock crevices and inside coral heads. They are therefore not at all easy to collect, but I believe that a little attention paid to them would bring the number of Philippine species of *Petroscirtes* up to 20.

Key to the Philippine species of Petroscirtes.

a^1. Marine species.
  b^1. Dorsal with 35 or more rays, and a median longitudinal band.
    c^1. Anterior dorsal rays not elongated.
      d^1. Blue, with black band from snout tip to end of caudal; dorsal and anal black, with white edges; dorsal 38 or 39. 1. *P. tæniatus.*
      d^2. Not blue.
        e^1. Dorsal 44 or 45; brown band from eye to caudal, with blue or white stripe above and below; fins yellow, unmarked. 2. *P. rhinorhynchus.*
        e^2. Dorsal 42 or 43; brown, with darker band; dorsal with 7, anal with 5 brown vertical bars; caudal with cross rows of brown dots .... 3. *P. amblyrhynchus.*
    c^2. Anterior dorsal rays elongated, most or all with elongated tips; dorsal 36 to 38; dark-brown band from tip of snout to caudal tip, with a blue or silvery stripe below dorsal base. 4. *P. filamentosus.*
  b^2. Dorsal with not more than 32 rays.
    c^1. Dorsal with 25 to 27 rays; a pair of flaplike tentacles under chin, another on eyes; other tentacles along margins of opercles and preopercles; caudal becoming lunate with age........ 5. *P. mitratus.*
    c^2. Dorsal with 27 to 32 rays.
      d^1. No longitudinal bands or stripes.
        e^1. No tentacles.

f^1. No crossbands or stripes on body. Olive to yellowish, with small brown spots and sprinkled with blue dots; fins yellow, dorsal and anal spotted and striped; dorsal 28; anal 19. 6. *P. bankanensis.*

f^2. Diagonal or angular crossbands on body.

g^1. Body with 11 angulated black crossbands, their angles pointing forward; a large black ocellus between the nineteenth and twenty-third dorsal rays........ 7. *P. kallosoma.*

g^2. Eight milk-white diagonal stripes, inclined backward along side, with wider blackish-brown stripes between them; a large black or dark-brown spot behind eye, margined with white lines; brown bands with white margins on throat and chin; dorsal 31 to 33; anal 22 or 23. 8. *P. loxias.*

e^2. Tentacles on eye, throat, nape, and top of opercle; color mottled brown, with whitish or blue spots and dots; fins yellow, barred with red-brown spots or bands; dorsal 27 to 30; anal 17 to 19 .... 9. *P. eretes.*

d^2. Body with one to several longitudinal bands or stripes.

e^1. A single broad black or blue-black band from eye to caudal. 10. *P. variabilis.*

e^2. Body with two or more lengthwise bands.

f^1. Two or 3 violet-brown bands; upper band from eye to top of caudal base, composed of short vertical violet-brown bars inclined backward.................... 11. *P. grammistes.*

f^2. Body with both dark and pearly white, bluish, or yellowish-white bands.

g^1. Short, broad tentacles on top of eye and behind upper rim, a pair of small tentacles on nape; a broad purplish-brown band from snout tip to caudal base; below this a pearly white band and below that a narrow dark-brown stripe from chin to caudal base; head, throat, and breast dotted with black.................... 12. *P. polyodon.*

g^2. No tentacles on head.

h^1. A violet-brown band over eye to middle of caudal and on basal third; above and below this band a yellowish-white band; a very dark stripe along dorsal base and a brown band from chin to caudal...... 13. *P. solorensis.*

h^2. Bluish to pearl, with 3 broad dark red-brown longitudinal bands, second and third band pale brown, with very dark circular spots as large, or larger than interspaces, bands ending before hind end of dorsal; circular dark spots on caudal peduncle and caudal base. Ground color forming bluish or pearly white stripes between dark bands.................... 14. *P. temmincki.*

a^2. Fresh-water species from Lake Bombon. Body with about 9 more or less angulate darker vertical bars....................15. *P. ferox.*

1. PETROSCIRTES TÆNIATUS (Quoy and Gaimard).

Aspidontus tæniatus QUOY and GAIMARD, Voy. Astrolabe Zool. 3 (1834) 719, pl. 19, fig. 4.

Petroscirtes tæniatus GÜNTHER, Cat. Fishes 3 (1861); Fische der Südsee 2 (1876) 195, pl. 114, fig. A; HERRE, Philip. Journ. Sci. 59 (1936) 372.

Dorsal 38 or 39; anal I, 25 or 26.

A specimen 93 mm long, from Calapan, Mindoro, has depth 4.9, head 4.2, truncate caudal 6.6 times in length; snout 3.14, eye 5.5, interorbital 3.4 times in head. Another specimen, 47 mm long, from Taruna, Sangi Island, one of the Sangir Group between Mindanao and Celebes, has depth 5.2, head 3.6, caudal 5.5 times in length. Eye 4.3, snout 3.25, interorbital 4.3 times in head. Mouth inferior, not reaching eye; blunt projecting snout becoming convex with age.

Blue, becoming more or less purplish brown in alcohol, with a black band from tip of snout to tip of caudal fin; narrow over eye but twice as wide on last half of body, covering the entire caudal fin except a narrow margin of blue (which becomes white in alcohol) above and below. Dorsal and anal black, with a narrow white margin.

I have also examined a specimen about 75 mm long at Dumaguete, Oriental Negros Province, and have seen this species at Sitankai, Bungau, Sibutu, and elsewhere in the Philippines.

This fish swims with a peculiar undulating and twisting motion that is very characteristic, swaying from side to side as it glides swiftly along. It is present on all coral reefs throughout the East Indies and Polynesia, but is very difficult to collect. It reaches a length of 126 mm, and is the handsomest blenny in Indo-Pacific waters.

This black-banded blue blenny has a very peculiar habit for which no explanation is yet offered. Very often it maintains its position beneath some much larger fish living on the reef. Like a shadow, the slender gleaming blue blenny twists and turns with every movement of the larger fish, always keeping the same relative position.

2. PETROSCIRTES RHINORHYNCHUS Bleeker.

Petroskirtes rhinorhynchus BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 273.

Petroscirtes rhinorhynchus GÜNTHER, Cat. fishes 3 (1861) 230; HERRE, Fishes 1931 Philippine Exp. (1934) 100.

Dorsal 44 to 45; anal 30 to 32.

Head 5.5 to 6.2, depth 6.2 to 8.2, caudal 5.6 to 6.2 times in length. Snout conical, projecting beyond mouth, which ascends

almost vertically; lower canines very large, no canines in upper jaw. Eye 3.5 to 3.9, interorbital 3.2 times in head.

A pale-blue line extending from top of snout above eye to caudal base at top of caudal peduncle; a similar line extending around tip of snout and over lower third of eye to pectoral, and on to lower end of caudal base. Between these two blue lines a broad brown or purplish-brown band, which extends well out on the caudal; a narrow brown band above upper blue line, another below lower blue line; fins all clear yellow.

In alcoholic specimens the blue lines become white.

A specimen I collected at Dumaguete, Oriental Negros Province, is 43 mm long, and 2 specimens obtained at Sitankai are 60 and 69 mm long. In addition I secured a specimen at Waigiu, 31 mm long, and 4 specimens, 33 to 39 mm long, at Madang, New Guinea. This species occurs from the East Indies to the New Hebrides.

3. PETROSCIRTES AMBLYRHYNCHUS Bleeker.

Petroscirtes amblyrhynchus BLEEKER, Act. Soc. Sc. Md. Neerl. 2 (1857) 64.

Petroscirtes amblyrhynchus WEBER, Fische Siboga Exp. (1913) 540.

Dorsal 42 to 43; anal 31.

Two specimens, each 34 mm long, were obtained from the south coast of Cotabato Province. Depth 6.8 (8 with caudal), head 4.25 (5 with caudal), caudal 5.66 times in standard length. Eye 3.45, interorbital 2.75 times in head. Canines of lower jaw stout; my specimens have none in the upper jaw. Snout conical, projecting; mouth inferior, caudal forked.

Alcoholic specimens brown, with traces of a median longitudinal band, extending on basal portion of caudal. Fins clear, dorsal with 7, anal with 5 brown vertical bars, caudal with transverse rows of brown dots; pectoral with a band of blackish dots on base.

I also collected the following: One from Lembeh Strait, 30 mm long, and 1 from Kema, North Celebes, 40 mm long; 1 of 33 mm from Ternate, and one of 32 mm from Manokwari, New Guinea.

This rare species was previously known only from 1 specimen from Amboyna, 1 from Salayer, and 7 from Banda, in the Moluccas.

4. PETROSCIRTES FILAMENTOSUS (Cuv. and Val.).

Blennechis filamentosus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 280, pl. 326.

Petroscirtes filamentosus GÜNTHER, Cat. Fishes 3 (1861) 231; Fische der Südsee 2 (1876) 196, pl. 114, fig. 5.

Dorsal 36 or 37; anal I, 25 to 27.

Body slender, elongate, much compressed laterally; depth 5.4 to 5.5, head 3.7, caudal 5.85 times in length. Snout conical, projecting well beyond mouth, its length 3.3 to 3.6, eye 4 times in head. Interorbital a little broader than an eye diameter. Mouth small, inferior, not extending back to a vertical from front margin of eye. Canines in lower jaw of moderate size, strongly hooked in a much flattened curve, so that they point backward; canines in upper jaw very small. First four dorsal rays elongated, first and second much the longest, all tips of dorsal rays more or less elongated and threadlike.

Alcoholic specimens violet-brown on upper half and posterior fourth of body, under parts very pale bluish pearl or silvery. A dark-brown band passes from tip of snout over eye and above pectoral base to caudal pit; on head it is about half as wide as eye, but broadens posteriorly so that it covers the caudal except for a narrow white margin above and below. A narrow blue or silvery stripe along back at dorsal base; this has disappeared on one side in my specimen. Dorsal dark violet-brown, with 7 whitish spots along basal half; these were probably blue or pearl-colored in life; anal and ventrals uniform dark violet-brown.

No Philippine specimens have been seen, but I collected an excellent specimen, 41 mm long, on the north coast of Celebes. Any fish occurring there may confidently be expected to occur in the Sulu Islands and on the coast of Mindanao. This easily recognized reef dweller occurs from the Moluccas to the Tuamotu Archipelago.

5. **PETROSCIRTES MITRATUS Rüppell.**

Petroscirtes mitratus RÜPPELL, Atlas Fische (1828) 111, pl. 28, fig. 1; KLUNZINGER, Fische Rothen Meeres pt. 2 (1871) 496; GÜNTHER, Fische der Südsee 2 (1877) 198; FOWLER, Proc. Acad. Nat. Sci. Phila. **89** (1927) 295.

Petroscirtes barbatus PETERS, Wiegmann's Archiv (1885) 248; SAUVAGE, Poiss. Madagascar (1891) 383, pl. 38, fig. 6; HERRE, Fishes 1931 Philip. Exped. (1934) 98.

Dorsal 25 to 27; anal 16 to 18.

Depth equal to or less than head, 3.66 to 4, head 3.4 to 3.66, caudal 4.36 times in length; snout equal to eye, 3.1 to 3.2 times in head. First three dorsal spines more or less elongated, fourth shorter than others, which are of uniform height except the three posterior spines, which are much shorter. Under the chin a pair of broad, flaplike, brownish barbels; on top of eye itself

a similar broad, flat, tentacle which may be slightly fringed; above front margin of eye a small, simple tentacle; immediately behind eye a very small tentacle; much farther back and opposite base of first dorsal spine a very small flap, another on upper margin of opercle; on lower and under margins of preopercle a row of very small flaps, the most anterior one largest. Any one of these opercular and preopercular flaps may be absent. Caudal broadly rounded in my specimens, but with age changing its shape and becoming lunate through growth of upper and lower marginal rays. Canines in lower jaw of moderate size, about 2.5 times in eye; upper canines very small.

Alcoholic specimens light brown, with 5 broad darker purplish-brown bands across body; in top of all except first band a very pale ocellated spot, traces of similar spots on sides; dorsal and anal spotted thickly with dots and blotches of reddish brown; caudal clear.

Three specimens, 13 to 24 mm long, were collected at Puerto Galera, Mindoro. Fowler described 2 examples from the Philippines, without more definite locality, their length "53 and 60 ? mm." Elsewhere this blenny is known from the Red Sea, Mozambique, and Madagascar, to the Caroline Islands and Samoa. It reaches a length of over 75 mm. According to Rüppell it remains out of the water for long periods, chasing its prey of minute crustacea over the rocks.

6. PETROSCIRTES BANKANENSIS Bleeker.

Petroskirtes bankanensis BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 727.

Petroskirtes amboinensis BLEEKER, Nat. Tijds. Ned. Ind. 4 (1853) 114.

Petroscirtes bankanensis GÜNTHER, Cat. Fishes 3 (1861) 237; WEBER, Fische Siboga Exped. (1913) 540.

A specimen 25 mm long was taken at Cabalian, Leyte. Dorsal 28; anal 19. Depth 5, head 3.8, caudal 4.15 times in standard length. Eye 4 to 4.5 times in head, 1.33 times in interorbital space. This specimen has no canines in the upper jaw, and no tentacles. Lower jaw with a pair of strong canines. Larger specimens have small canines above, and a small tentacle behind the upper margin of the eye. Dorsal origin above hind edge of preopercle.

Olive above, yellowish below, with small brown spots and sprinkled with blue dots, which fade in alcohol. Fins yellow, dorsal and anal spotted with dusky and variegated with reticulated lines or stripes of dusky. Caudal unmarked.

Bleeker had a specimen, 120 mm long, from Banka. He also obtained it from Singapore and Nias, and Doctor Weber secured it from several places in the East Indies.

7. **PETROSCIRTES KALLOSOMA** Bleeker. Plate 2.

Petroskirtes kallosoma BLEEKER, Nat. Tijds. Ned. Ind. 15 (1858) 227.
Petroscirtes kallosoma WEBER, Fische Siboga Exp. (1913) 541.

Dorsal 30 to 32; anal II, 18 to 21.

Greatest depth at dorsal origin, which is over the gill opening. Depth 6, head 4.6, caudal 3.3 times in length. Eye 3.25, snout 4.33 times in head. Upper and lower rays of caudal prolonged.

Alcoholic specimens dark brown, with black spots on lower half of head, breast, and pectoral bases. On the body are 11 angulated black crossbands, their angles pointing forward, with a black spot on each angle. Dorsal brownish, with pale or white longitudinal lines, and a large black spot above between nineteenth and twenty-third rays; anal reddish brown, becoming darker marginally, tips of rays white; caudal pale, tinged with dusky.

Two specimens, each 30 mm long, were collected at Nasugbu, Batangas Province.

This blenny is known elsewhere only from Billiton, Bima, and North Celebes, in the East Indies.

8. **PETROSCIRTES LOXIAS** (Jordan and Seale).

Hypleurochilus loxias JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 802, fig. 20.
Petroscirtes loxias HERRE, Fishes 1931 Philip. Exped. (1934) 98.

Dorsal 31 to 33 (XII, 19 to 21); anal I, 21 or 22; pectoral 13; caudal 13.

Depth 5.6 to 6, head 4.25 to 4.35, rounded caudal 6.4 to 6.5 times in length. Eye 4.3 to 4.45, snout 3.2 to 3.4 times in head; interorbital width a little more or less than half of eye. Mouth extending beneath middle of eye, with 24 teeth in both upper and lower jaws; a large stout canine on each side of both upper and lower jaws, or those of upper jaw quite small.

Alcoholic specimens brown to yellowish brown, with 8 conspicuous milk-white diagonal or curved stripes inclined backward along side; between them equally conspicuous wider blackish-brown stripes; both kinds of stripes shorter posteriorly, followed by 2 irregular brown spots on caudal peduncle; often white stripes fading to pale brown. Across back 7 or 8 double

crossbars of blackish brown, which extend as spots on base of dorsal fin. Alternating with stripes a row of blackish-brown spots along upper part of side. From front and back of eye 2 white-margined brown bands passing under chin and uniting with those of other side. Behind eye a highly characteristic and conspicuous black or very dark-brown spot, margined with milk-white lines that extend down across the check and opercle. Fins all clear and colorless except anal, which has a basal row of dark-brown spots and a dark-brown submarginal band, tips of rays white.

I have collected specimens of this very well-marked and handsome species as follows: two from Nasugbu, Batangas Province, 28 and 35 mm long; 1 of 26 mm from Culion; 2 from Opon, Mactan Island, 30 and 39 mm; 2 from Bais, Oriental Negros Province, 27 and 29 mm; 3 from Dumaguete, Oriental Negros Province, 29 to 33 mm; and 1, 45 mm long, from Sitankai. It also occurs on reefs at Singapore.

9. **PETROSCIRTES ERETES Jordan and Seale.**

Petroscirtes eretes JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 801, fig. 19; Bull. Bur. Fish. **26** (1907) 47; JORDAN and RICHARDSON, Bull. Bur. Fish. **27** (1908) 283; HERRE, Fishes 1931 Philip. Exped. (1934) 98; Bull. Raffles Mus. No. 13 (1937) 48.

Petroscirtes vulsus JORDAN and SEALE, Bull. Bur. Fish. **26** (1907) 47, fig. 20.

Dorsal 27 to 30; anal II, 15 to 18.

Depth 4.5 to 5, head 4 to 4.2, caudal 1.1 times in length. Eye 3.5 to 3.75 times in head. Body elongate, compressed, with a long convex snout. Mouth extending back beneath pupil, with a pair of large strong canines in lower jaw and a pair of much smaller ones above.

A small and rather broad simple tentacle at top of each eye, a pair of slender simple tentacles on throat some distance from chin, a pair of minute simple tentacles on nape, a similar pair on upper margin of opercle. Last-named two pairs may be broad flaps, and either pair may lack one member.

Alcoholic specimens mottled brown, with whitish spots and dots which are blue in life. Five broad vertical brownish or dusky bands across sides of body, which are often indistinct or disappear in preservative. Dorsal barred by longitudinal rows of reddish-brown spots on first half, and diagonally downward and backward rows on second half; anal with 4 or 5 vertical or

diagonal brown bands, and may be spotted as well. The yellow caudal may also be cross-barred with brown spots. Dorsal and anal both with outer margin yellow.

The Stanford University museum contains the type of *P. vulsus*, 45 mm long, from Manila, and two cotypes of *P. eretes*, 37 and 81 mm long, from Bais, Oriental Negros Province. The following Philippine specimens were also examined: One of 41 mm from Culion; 1 of 62 mm from Cuyo, Palawan; 5 from Dumaguete, Oriental Negros Province, 25 to 50 mm long; 1 of 62 mm from Magallanes, Sorsogon Province; 1 of 28 mm from Nasugbu, Batangas Province; 8 from Puerto Galera, Mindoro, 25 to 59 mm long; and 1 of 21 mm from Sitankai. In addition, I collected 4 in the Pelew Islands, 65 to 70 mm long, and 7 at Singapore, from 44 to 66 mm long. The distribution is as given above.

10. PETROSCIRTES VARIABILIS Cantor.

Petroscirtes variabilis CANTOR, Cat. Malayan Fishes (1850) 200; DAY, Fishes India (1876) 327, pl. 69, fig. 7.

Dorsal 28 to 31; anal II, 17 to 19, or I, 19.

Depth 5 to 6.4 times, head 3.6 to 3.7, caudal 4.5 to 5 in length; young have caudal 6 times in length. Eye 4 to 5, snout 3.3 to 3.55 times in head; interorbital width equal to eye, or 1.5 times eye.

Snout truncate, longer than eye, mouth terminal, in large specimens extending to a vertical from front margin of pupil; lower canines very strong, three-fourths as long as eye; upper canines very small. A very small, simple tentacle on upper rim of eye, some specimens also with a pair of very small, flat tentacles some distance dehind chin.

Alcoholic specimens reddish brown, often with a bluish cast; a broad black or bluish-black band extending from eye to caudal, with a black or dusky bar across caudal base. Dorsal and anal yellow, rays with diagonal rows of black spots; caudal yellow, may also be barred with rows of dusky spots.

Some specimens are so faded as to be almost uniform brown, with only a trace of the black median band on the basal portion of the caudal, which is densely sprinkled with black dots.

A specimen 36 mm long was collected on the south coast of Cotabato Province, near Kling. I also collected 1 specimen of 85 mm at Sandakan, British North Borneo, and 6 from 44 to 71 mm long on a reef at Singapore. This blenny occurs from the Philippines to India.

11. PETROSCIRTES GRAMMISTES (Cuv. and Val.).

Blennechis grammistes CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 210.

Petroscirtes grammistes GÜNTHER, Fische der Südsee 2 (1877) 197, pl. 115, fig. F; MEYER, An. Soc. Esp. Hist. Nat. Madrid 14 (1885) 31; EVERMANN and SEALE, Bull. Bur. Fish. 26 (1907) 104.

Petroskirtes anema BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 273.

Petroscirtes anema MEYER, An. Soc. Esp. Hist. Nat. Madrid 14 (1885) 31.

Dorsal 28 to 30; anal I or II, 16 to 18. Depth contained 7, head 4.6, caudal 3.5 times in length; eye 3.8, snout nearly vertical, 4.6 times in head; interorbital 1.5 times in eye. Dorsal origin immediately behind rear margin of eye; lower canines of moderate size, their length about one-third of eye; upper canines very small. Large specimens with a pair of small filamentous tentacles on throat, a very small pair very close together on nape, another very small pair on upper margin of opercle.

A band composed of short, vertical, violaceous-brown bars, inclined backward, passing from eye to upper end of caudal base, then bending toward middle, extending centrally half length of caudal; a similar diagonal stripe running back on caudal from lower end of base; a violaceous-brown band along dorsal base merging on caudal peduncle with band below it; a third dark-violet band present in life above anal but in preserved specimens often largely disappearing, leaving only portion mentioned on caudal; anterior dorsal rays entirely dark brown, rest of dorsal clear except basally; anal with a marginal brown line.

Philippine specimens were examined as follows: One from Subic, Zambales Province, 53 mm long; 2 from Puerto Galera, Mindoro, 24 and 53 mm long; 2 from Legaspi, Albay Province, 38 and 50 mm long; 2 from Dumaguete, Oriental Negros Province, 37 and 44 mm long. I also collected a specimen 54 mm long at Singapore. This species has been collected previously in the Philippines at Bacon, Sorsogon Province, and at Cebu. Elsewhere it occurs from Java to Yap.

12. PETROSCIRTES POLYODON Bleeker.

Blennechis polyodon BLEEKER, Nat. Tijds. Ned. Ind. 1 (1851) 254.

Petroscirtes polyodon GÜNTHER, Cat. Fishes 3 (1861) 235.

Dorsal 28 to 30; anal II, 16 to 18.

Depth 4.25 to 4.5, head 3.5 to 3.75, caudal 4.8 to 5.2 times in length; interorbital width equal to eye, 3.5 times in head; snout broad, convex, a little longer than eye; mouth terminal, cleft extending beneath front margin of eye; strong canines in lower

jaw half as long as eye; those of upper jaw about one-sixth eye diameter. On upper part of eye a short broad flap, and a similar tentacle right behind it, behind rim of eye; a pair of small tentacular flaps may be present on nape.

Alcoholic specimens light brown, with a broad, dark, more or less purplish-brown band from tip of snout to caudal base; below this a pearly white band, likewise extending from snout tip to caudal base, and below this is a narrow dark-brown stripe from chin to caudal base; sides of head, throat, and breast dotted with black, or head and dorsal portion of trunk mottled with paler and dusky brown. Dorsal dotted with brown, most specimens with a pale longitudinal stripe on upper part; on anal 5 dark-brown bands, which extend a short distance on body above.

I collected 13 specimens, 13 to 53 mm long, from a reef near Dumaguete, Oriental Negros Province. Previously known from Java, Celebes, and Amboyna. Bleeker had a specimen 87 mm long from Batavia, Java.

18. PETROSCIRTES SOLORENSIS Bleeker.

Petroskirtes solorensis BLEEKER, Nat. Tijdschr. Ned. Ind. 4 (1853) 81.

Dorsal 30, anal 20; depth 5.33, head 4, caudal 5 times in length; snout convex, equal to eye, 3.4, interorbital 3.8 times in head; lower canines robust, more than half eye, upper canines very small, 10 or 11 times in eye; dorsal origin over posterior margin of preopercle.

A violaceous-brown band passing over eye to middle of caudal and out for a third of its length; a yellowish-white band from upper margin of eye to caudal and one from upper lip to caudal; a very dark violaceous-brown stripe along dorsal base to caudal and a brown band from chin to caudal base, the two last-named converging on caudal to central band; dorsal brown, with three rows of darker-brown spots; anal brown, more or less clouded.

The following were examined from the Bureau of Science collection: A specimen 58 mm long from Clarendon Bay, Balabac; 1 of 34 mm from Cabalian, Leyte; and 1 of 75 mm from South Ubian, Sulu Archipelago.

In life the South Ubian specimen had a blackish-green band from the tip of the snout through the eye to the caudal, ending in a conspicuous spot on the caudal base; a yellow band above and below the median band; a black band along the dorsal base, and another from the angle of the mouth to the tail.

Previously known only from Solor, one of the Lesser Sunda Islands.

14. PETROSCIRTES TEMMINCKI Bleeker.

Petroskirtes temmincki BLEEKER, Nat. Tijdschr. Ned. Ind. 2 (1851) 243.

Dorsal 30 or 31; anal I, 15.

Depth 4 to 4.7, head 3.8 to 4 times in length. With age the upper and lower marginal rays of the caudal fin become elongated and threadlike, so that the length of the caudal fin is then 3 to 4 times in the head and body together. Eye 3.25 to 3.5, snout 3.7, breadth of interorbital 4 times in head. There are no tentacles. Profile boldly convex from dorsal origin to terminal mouth, which extends to beneath front margin of eye. Lower canines strong, half or more than half as long as eye; upper canines very small.

Pale blue to pearl, with three broad, dark, reddish-brown or violet-brown bands along side; first running from interorbital along back just below dorsal to its posterior end; second passing around snout and across eye, ending a little before hind end of dorsal; third running from tip of lower jaw back to pectoral, forming a large circular spot on its base; it then continues from the pectoral axil back to the caudal peduncle. Second and third band formed of a paler-brown stripe on which are very dark circular spots, as large or larger than interspaces; similar spots on caudal peduncle and caudal base, forming a characteristic recognition mark. Ground color appearing as bluish or pearly white stripes between dark-brown bands. Dorsal fin brown below, with a submarginal blackish-violet stripe or row of spots, middle of fin bluish or pearly. Anal yellowish, with one or two rows of violet-brown dots between rays; yellow caudal with a dark violet-brown upper margin and sprinkled with rather large dark-brown spots on rays.

Four specimens were obtained at Cebu, 48 to 61 mm long. Elsewhere the species is known from the Moluccas and Singapore.

15. PETROSCIRTES FEROX Herre. Plates 3 and 4.

Petroscirtes ferox HERRE, Philip. Journ. Sci. 34 (1927) 277, pl. 3, figs. 2 and 3.

Dorsal 32 to 36, mostly 33 or 34; anal 24; pectoral 12; caudal 12, not counting the short accessory rays; ventral 2.

Body wedge-shaped, elongate, laterally compressed, its greatest depth just back of pectoral base, 5.5 to 6 times in length; caudal rounded, equal to depth; dorsal profile nearly horizontal, highest at origin of dorsal and descending at a very slight angle in a straight line to caudal base; ventral profile strongly convex below head and belly, then ascending in a moderate straight incline to caudal base; upper anterior profile of head boldly convex; eye 3.66 to 4 times in head, equal to steeply curved snout; interorbital width equals half or two-thirds eye; mouth low down, inferior, apparently very small, lip concealing its posterior angle which is beneath anterior margin of eye; 16 to 18 teeth in upper jaw, 18 in lower jaw; a long, stout, recurved canine tooth on each side of both jaws, lower canines much the larger, their length equal to or greater than diameter of pupil of eye; no tentacles or barbels; dorsal and anal extending to, but not upon caudal; dorsal of almost uniform height, equal to or greater than an eye diameter in vertical height, posterior rays elongate and equal to depth.

Alcoholic specimens varying from light brown to brownish green or brownish gray, underparts paler, body crossed by about nine darker vertical bars; often bars, especially forward ones, angled, point of angle directed forward; dorsal, anal, and caudal uniform dark brown, or concolorous with body; pectoral pale, ventrals whitish.

Here described from 60 specimens, 31 to 56 mm long, from the vicinity of Ambulong, Talisay, and around Volcano Island, all in Lake Bombon. They live amid stones and gravel. When held in the hand they will snap at skin or finger nails and hang suspended by their teeth.

This little blenny is the only fresh-water species known from the Philippines.

Genus ENCHELYURUS Peters

Enchelyurus PETERS, Monatsber. Akad. Wiss. Berlin (1868) 268.

This genus is closely related to *Petroscirtes*, but differs as follows: (*a*), the dorsal and anal are both united to and more or less confluent with the caudal; (*b*), the gill opening is wider, extending downward as far, or nearly as far, as the lower end of the pectoral base.

A small genus, containing 4 or 5 inconspicuous species found in the East Indies and tropical Pacific. Two species are known from the Philippines. It is possible that the discovery of additional species, or the study of very large series of known species,

may show the genus to be a synonym of *Petroscirtes*. The differences which separate *Enchelyurus* and *Petroscirtes* are not profound, and the examination of very large numbers of various species of both groups may show transitional stages, thus eliminating *Enchelyurus*.

Key to the Philippine species of Enchelyurus.

a^1. Uniform black or blackish brown, or with caudal, pectorals, and ventrals yellow or pale; dorsal 31 to 33; anal II, 20; pectoral 16.... *E. flavipes.*

a^2. Everywhere indigo to blue-black, with 2 rows of sky-blue spots along sides, on dorsal, and anal; dorsal 28; anal II, 18; pectoral 13. *E. cæruleo-punctatus.*

1. **ENCHELYURUS FLAVIPES** Peters.

Enchelyurus flavipes PETERS, Monatsber. Akad. Wiss. Berlin (1868) 268; HERRE, Bull. Raffles Mus. No. 13 (1937) 47.

Enchelyurus flavipes var. *nigerrima* M. WEBER, Fische Siboga Exped. (1913) 545; HERRE, Fishes 1931 Philip. Exped. (1934) 98.

Dorsal 31 to 33; anal II, 20; pectoral 16; ventral 2.

Depth 4.65 to 5.5, head 3.9 to 4, caudal 5 to 5.35, broadly rounded pectoral 5.35 to 5.5 times in length. Eye 4.25 to 5, convex and nearly vertical snout 5 times in head. Angle of mouth beneath hind margin of eye; a very large posterior canine on each side in lower jaw, a smaller pair in upper jaw. Caudal rounded to somewhat pointed. Ventrals 6 to 8 times in length in young, but they become elongated with age; in females they nearly reach the anus, but in mature males they may extend upon the anal fin, 3.7 to 4 times in length. Dorsal undivided, increasing in height posteriorly; tips of anal rays more or less enlarged posteriorly.

Typical form uniform blackish brown or black, including vertical fins, with an elongate yellow spot covering most of caudal fin; rarely yellow may extend forward to include rear end of body and adjacent parts of dorsal and anal. Dorsal with a narrow white or pale margin, usually covered by parallel pale lines (blue in life?) on upper part of anterior half; sometimes they are on the lower part also, more rarely absent. Tips of anal rays white, anal with 2 to 4 faint pale-blue longitudinal lines. Pectorals and ventrals yellow. In alcoholic specimens the yellow fades to white or colorless.

My only Philippine specimen belongs to the variety *nigerrima*. It is 33 mm long, entirely black, body and all fins with longitudinal lines previously mentioned on dorsal and anal; taken by me at Culion.

Peters had 2 specimens of the typical form, each 60 mm long, collected at Singapore.

Dr. Max Weber described the variety *nigerrima* from 2 specimens, 62 and 75 mm long, taken near Makassar.

The only other specimens of this species known are 21 examples of the typical form, 36 to 59 mm long, which I collected from a reef at Singapore.

2. **ENCHELYURUS CÆRULEO-PUNCTATUS** sp. nov. Plate 1.

Dorsal 28; anal II, 18; pectoral 13; caudal 13.

Depth 4.5, head 4.15 to 4.2, caudal 5.4, pectoral 5 times in length; ventral equal to pectoral, not reaching anus. Eye equal to snout, 3.6 to 3.7, depth of caudal base 2.5 times in head. Eyes very close together, interorbital breadth 5 times in an eye diameter.

Body laterally compressed, dorsal profile horizontal, ventral outline in an arc, depth greatest at dorsal origin, which is over the opercle; snout convex, nearly vertical; mouth small, its angle beneath front rim of eye; a pair of stout canines in lower jaw, those of upper jaw half as large; small gill opening above and in front of pectoral base, equal to diameter of eye; dorsal and anal both attached to caudal base, but not completely confluent with it, as in other species of genus.

Head, body, dorsals, anal, and caudal very deep indigo or blue-black, with 2 rows of small sky-blue spots on side, median row beginning at upper angle of opercle, the other behind lower part of pectoral; 2 similar rows on dorsal and anal, and 2 or 3 cross rows on caudal; tips of dorsal and anal rays pale.

The type, 30 mm long, and paratype, 27 mm long, were collected from a tide pool among the rocks at Nasugbu, Batangas Province, Luzon. The gill opening extends downward below the middle of the pectoral base. A very handsome little blenny in life.

Genus ANDAMIA Blyth

Andamia BLYTH, Journ. Asiat. Soc. Bengal (1859) 270.

This remarkable genus differs from *Salarias* in having an adhesive disc or sucker on the lower jaw, immediately behind the mouth. Caudal rays not branched. Head broad, somewhat depressed anteriorly; eyes small, dorsolateral in position and from an eye diameter apart in the young to nearly 2 diameters apart in adults. Males have dorsal rays more or less elongated, especially anterior ones. Orbital tentacle present.

Very active slender fishes living on exposed rocks on the outer reefs and surf-beaten coasts, and spending a great deal of time out of the water. Two species are known. One species occurs from the Nicobar Islands and Andamans to the Moluccas, the other is found from the Philippines through the East Indies to New Guinea.

ANDAMIA REYI (Sauvage).

Salarias reyi SAUVAGE, Bull. Soc. Philomat. IV (1880) 219.
Andamia cyclocheilus M. WEBER, Fische Siboga Exped. (1913) 538, pl. 3, fig. 3; HERRE, Philip. Journ. Sci. 59 (1936) 370.

Dorsal XV, 19 or 20; anal 24 to 26.

Depth 7.33, head 5.5, caudal 3.3, pectoral 5 times in length; eye 3, snout 2.4, interorbital 4, ventral 2.4 times in head. Second and third dorsal spines a little elongated. There is a fimbriated ocular tentacle.

Large males have the anterior dorsal spines, or all the dorsal spines except the first, much elongated. Caudal rays undivided, tips filiform, free. A male 77 mm long has depth equal to head, 6 times, caudal 3.35, pectoral 5.1, ventral 11, second dorsal spine 3.2 times in length; eye and interorbital equal, 4.33 times, snout and ventral each 1.85 times in head.

Alcoholic specimens uniform purplish brown or blue-black, with or without 10 to 12 paler violet or whitish spots and short irregular bars over head, back, and sides; dorsal, caudal, and pectoral brown, brownish black, violaceous, or colorless; anal may be colorless, or blackish-blue with white margin; ventral white.

From *Andamia expansa* Blyth this species is separated by the shape of its adhesive sucker, which is a semicircular or oval disc behind the mouth, instead of the double-pointed one of *A. expansa.*

I have collected Philippine specimens as follows: One of 25 mm at Nasugbu, Batangas Province; 1 of 50 mm at Layia, Batangas Province; 1, 58 mm long, at Calapan, Mindoro; 4, 48 to 66 mm long, at Puerto Galera, Mindoro; and 1, 61 mm long, on the south coast of Cotabato Province. I also obtained 3, 46 to 56 mm long, at Taruna, Sangi Island, in the Sagir group; 20, from 28 to 77 mm long, at Lembeh Strait, Celebes; and 1, 63 mm long, on the coast of Sarawak, Borneo. Sauvage had a specimen 70 mm long, collected by Mantano and Rey on the coast of Tayabas Province.

Weber had a specimen from New Guinea, 3 from Flores, and one labeled "East Indies." It is not rare, as has been hitherto supposed, but is common enough if one knows where to look for it.

This extraordinary slender little blenny lives on the outer face of rocks jutting into the sea, and scampers or leaps about as actively as a lizard. Its adhesive disc enables it to cling to vertical rocks above the water. Although it lives where the water is constantly in motion and highly aërated, it seems to need more oxygen and hence takes to the air. It is as keen-eyed as *Periophthalmus barbarus*, or *Periophthalmodon schlosseri*, and at the first sight of a human being, bird, or other enemy, bounds off, usually into the water, and hides in a crevice. This species evidently occurs commonly in suitable places from the shores of Celebes to the coast of Luzon, but is very rarely taken because of its excellent vision and great agility. The only way I have been able to take these fishes has been by wading out along the side of some rock where they were hanging above the water. Then with a long-handled dip net in hand, I would step out in front suddenly and make a wild dash with the net before all could escape. In this way I have secured them in Celebes and in the Philippines.

Key to the East Indian species of Cirripectes.

a^1. Yellow to light brown, with dark-brown spots on head and forward part; dorsal and pectoral brown-spotted. Dorsal XII, 12; anal II, 13. *C. caninus.*

a^2. Body and fins black to dark brown; dorsal XI or XII, 15; anal I or II, 15 or 16 .... *C. variolosus.*

1. CIRRIPECTES CANINUS Herre.

Cirripectes caninus HERRE, Philip. Journ. Sci. 59 (1936) 284.

Dorsal XII, 12; anal 15, ventral 3; pectoral 15. Head equal to depth, 3.28 times in length; caudal 4.6, pectoral 2.875 times in length; eye 2.9, snout and interorbital each 3.5 times in head; depth of caudal peduncle equal to eye; ventral 1.75 times in head.

Body compressed-ovate, deepest just behind pectoral base, anterior profile descending at an angle of about 45° from over eye to tip of snout. Mouth small, its angle beneath front margin of eye. Lower jaw with 4 hooked canines near symphysis, with a single row of very small teeth behind them; upper jaw teeth similar, canines much smaller.

On nape a row of 26 tentacles, some of them broad and bifid. On anterior nostril a short, broad, fringed tentacle; none on eye

or elsewhere. Dorsal entirely free from caudal, latter rounded, its central rays longest.

Yellow, with large brown spots between pectoral and dorsal, and small brown spots all over head and on pectoral base; 10 blackish-brown spots or vertical bands on dorsal; brown spots on pectoral, tips of rays black; other fins colorless. After some years in alcohol the yellow has become light brown.

The type and only specimen, 22 mm long, was taken by me with an electric light at Ternate, one of the Moluccas. This blenny may be expected around the Sarangani Islands, on the south coast of Mindanao, and among the Sibutu Islands.

2. **CIRRIPECTES VARIOLOSUS** (Cuv. and Val.).

Salarias variolosus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 317, pl. 330; GÜNTHER, Fische der Südsee 2 (1877) 203, pl. 116, fig. A.

Cirripectes variolosus SWAINSON, Nat. Hist. 2 (1839) 275; FOWLER, Fishes Oceania, Mem. Bishop Mus. 10 (1928) 434; HERRE, Fishes 1931 Philip. Exped. (1934) 100.

Dorsal XI or XII, 15; anal II, 16.

Depth 3.15, head 3.3 to 3.4, caudal 3.75 times in length. Eye 4.25 to 4.4, snout 2.75 to 2.8 times in head.

Strongly compressed, with rather broad head, anterior profile convex with vertical or nearly vertical snout; eyes prominent, projecting upward, and with a slender tentacle of 2 long slender threads on the upper margin. On nape a long row of short filaments; nasal filaments fringed and rather long. Upper lip crenulate or finely scalloped; a stout canine on each side of lower jaw. Dorsal high, anterior rays often very long with threadlike tips, more or less attached to caudal. Large specimens have anal spines much thickened and bulbous, their surface gyrose.

All black or deepest chocolate brown, with elongated dorsal spines and upper and lower parts of caudal more or less colorless; alcoholic specimens may fade to dull uniform brown, fins remaining black.

I collected the following Philippine specimens: three from Dumaguete, Oriental Negros Province, 44 to 66 mm long; 2 from San Juan, Siquijor, 38 and 42 mm long; 2 from Sitankai, 65 and 74 mm long. I also obtained 2 young specimens, 16 and 31 mm long, at Waigiu. The Stanford Museum has 5, from 40 to 46 mm long, from Apia, Samoa.

This little blenny is found all over the tropical Pacific. It reaches a length of 92 mm.

Genus SALARIAS Cuvier

Body usually slender and elongate; skin naked, lateral line little developed. Movable teeth numerous, implanted on gums; a pair of curved canines, often long and strong, may be present on posterior part of lower jaw; simple or fringed tentacles may be present on eye, nape, and nostril. A median longitudinal skinny crest may be present on top of head; it is found on males only, except in two or three species. Philippine specimens with crests may be safely regarded as males; some species never have a crest. Dorsal rather high and may be entire, but usually more or less deeply notched between spinous and rayed portions; it may be free from the caudal or more or less attached to it. Jugular ventrals consisting of a spine and 2 or 3 rays. Gill opening wide, forming a free fold across isthmus.

Herbivorous fishes common on reefs and rocky shores in all warm seas, numerous species in the tropical Pacific. Most members of the genus are very agile, and well deserve their name of rock skippers, or lizard skippers. When the tide goes out they remain in rock pools, or on exposed rocks, where they browse on algæ. Some species leap about with all the speed and agility of lizards. They lack the brilliant and vivid colors of many small coral-reef fishes, the red, orange, yellow, blue, violet, crimson, and green of butterfly fishes, labrids, and damsel fishes. Nevertheless they are often very handsome, with rich quiet harmonious colors in various shades and markings of brown, gray, reddish, bluish, purplish, and black. To see them at their best, and to gain some idea of their life and habits, one should visit some bold and rocky coast, approaching cautiously, at low tide, small but rather deep pools in the rocks and observing the rock skippers. Some will be clinging quietly to the walls of the pools and some swimming about; almost certainly some will be moving around out of the water. Usually several species may be seen in a pool, and the different behavior of various species compared. Whoever makes an attempt to catch some, will form a new conception of the astonishing physical powers of some fishes, and the limitations of man. To see a rock skipper go bounding away in great flying leaps to deep water and safety, or jump from one roughness to another as it surmounts a nearly vertical ledge of rock a meter and a half high and then with a few great skips is gone into the surf, is to witness one of the most surprising and unfishlike performances in the world.

The identification of rock skippers is often very difficult. The characteristic colors and markings of many kinds often change or disappear very quickly after death, while many species of very different appearance come to look alike after being in preservative for a time. To determine them it is necessary to examine a large series of both fresh and preserved material. The number of dorsal and anal spines and rays, the shape and extent of the dorsal, and the development of the tentacles and crest will usually make it possible to name specimens without difficulty if a goodly number are available for study and comparison. Fortunately a few well-marked and strongly characterized species never lose their identification marks.

The 19 species of *Salarias* here mentioned are by no means all that live in Philippine waters. Further collecting will unquestionably reveal most of those known from the Dutch East Indies. I do not doubt the occurrence of at least 25 species of *Salarias* in the Philippines, and the number may prove to be greater.

Key to the Philippine species of Salarias.

*a*¹. Dorsal not notched.

*b*¹. Body uniformly dark brown or black; fins all dark or caudal yellow; dorsal and anal elongate posteriorly, sometimes for half or three-fourths of caudal length; dorsal 29 to 31; anal II, 18 or 19.
1. *S. fuscus.*

*b*². Not uniformly dark brown or black.

*c*¹. Dorsal attached to caudal.

*d*¹. Brown, thickly sprinkled with blue-black dots; dorsal and caudal with cross rows of spots and bars; no canines; broad, palmately fringed tentacles on eye and nape; dorsal 29 or 30; anal I, 18 or 19 .... 2. *S. ceramensis.*

*d*². Seven wide, dark crossbands; black dots and dashes above pectoral, passing into longitudinal lines along side; large circular white or pale spots below lines and on pectoral base; broad fringed tentacles on eye, nape, and nostril.......... 3. *S. fasciatus.*

*c*². Dorsal free from caudal; 2 or 3 rows of elongate brown-edged white spots on sides and small circular ones on head; no violet or blue spots on throat; small canine in lower jaw; minute tentacles on eye and nape; dorsal XII or XIII, 19 to 22; anal II, 22, or I, 23.
4. *S. nitidus.*

(*S. alboguttatus*, a Polynesian species, has a large violet-brown or dark spot on each side of the throat.)

*a*². Dorsal more or less deeply notched.

*b*¹. A longitudinal crest along top of head.

*c*¹. Dorsal XV, 19; anal II, 20; a stout, marginally fimbriate, orbital tentacle and fringed nasal tentacle; uniform light brown with 8 broad, dark crossbars, divided below, and a basal caudal band.
5. *S. colei.*

c^2. Dorsal with XII or XIII spines.

d^1. Two rows of short blue or pearly bars on sides; a circular blue-black spot at upper angle of opercle; a blue bar below and a blue spot behind eye, often turning black; dorsal XII, 20 or 21; anal I or II, 20 or 21; a long simple orbital tentacle.
6. Males of *S. periophthalmus*.

Also with 4 to 8 longitudinal brown lines along middle of side.
S. periophthalmus var. *visayanus*.

d^2. Without rows of blue or pearly bars on side.

e^1. Five to seven dark or black longitudinal lines on sides.

f^1. Pale brown, with 5 to 7 very dark lines along sides, breaking posteriorly into dots and dashes; a small orbital tentacle; canines present or absent in lower jaw.
7. Males of *S. caudolineatus*.

f^2. Brown or leaden, with 5 to 7 darker lines along sides; not breaking up posteriorly, crest low; no canines; orbital tentacle finely fringed, and a smaller nasal one; dorsal XII, 23 or 24; anal II, 23 or 24................ 8. Males of *S. lineatus*.

e^2. Without several parallel dark lines along sides.

f^1. Sides with many violet crossbands, wider than interspaces, breaking up into irregular vertical lines posteriorly; no canines; orbital tentacle three-fourths of eye, simple or fringed; nasal tentacle small; dorsal XIII, 19 to 21; anal I, 21 or 22, or I or II, 19 or 20............................ 9. *S. oorti*.

f^2..Not as above.

g^1. Dorsal XII or XIII, 17 or 18; anal I or II, 16 to 18; 7 or 8 broad, forked, dark crossbands, extending on basal half of dorsal; 2 rows of white dots on sides; similar blue dots on top of head, all dots usually brown in preserved specimens; orbital tentacle simple or fringed, and minute fringed nasal tentacle................................ 10. *S. bilineatus*.

g^2. Dorsal XII or XIII, 19 to 22; anal I or III, 20 to 24; dorsal attached to caudal.

h^1. Dorsal XIII, 19 to 21; anal I, 20 to 22; nape and orbital tentacles small; nasal tentacle very small, usually composed of 4 filaments; uniform brown, or with darker crossbars; anal with 2 rows bluish spots, or uniform; a diagonal dark bar behind eye, often disappearing.
11. Males of *S. edentulus*.

h^2. Dorsal XII or XIII, 20 to 22; anal I, 23 or 24, or II, 21 to 24, or III, 22; orbital tentacle equal to or more than eye, tip and marginal filaments white or pale; 7 double brown crossbars, 2 rows brown dots on lower half posteriorly; dorsal, caudal, and anal white-margined .... 12. Males of *S. zamboangæ*.

b^2. No crest on head.

d^1. Upper lip crenulate or denticulate.

e^1. Dark lines from eye over snout, sides of head, and throat; no tentacles on nape; dorsal XIII, 15 to 17; anal I, 17 to 19 or II, 16 or 17 .... 13. *S. frenatus*.

e[2]. Sides brown mottled, with row of white spots just below median line; a black spot above pectoral base and black streak behind eye; dorsal XII or XIII, 14 to 16; anal I or II, 16 or 17.
14. *S. marmoratus.*

d[2]. Upper lip entire.

f[1]. Dorsal with less than 19 rays.

g[1]. A purplish or brown spot or ring on each side of throat; body pale brown, or with double white crossbands, forked below; black dots in irregular rows on sides, or a row of 17 to 19 below dorsal; 1 or 2 large circular white or pale spots on pectoral base; 2 irregular rows or white spots on lower half of head and body; canines absent or present. Dorsal XII or XIII, 17 or 18; anal I, 18 or 19.
15. *S. guttatus.*

g[2]. Without purplish or dark spot or ring on each side of throat; anterior half with many black dots, merging into lengthwise lines and stripes; orbital tentacle longer than eye, fringe-edged; nasal tentacle palmate; dorsal XIII, 15 to 17; anal II, 16 to 18.................... 16. *S. aneitensis.*

f[2]. Dorsal with 19 or more rays.

g[1]. Sides with 2 rows of short blue or pearl bars; a circular blue-black spot at upper angle of opercle; a blue bar below, and a blue spot behind eye, blackening in preservative; a small canine below; small simple orbital tentacle; dorsal XII, 20 or 21; anal I or II, 20 or 21.
6. Females of *S. periophthalmus.*

Also with 4 to 8 brown lines from near tip of pectoral to above middle of anal.
S. periophthalmus var. *visayanus.*

g[2]. Without blue or pearl bars along sides.

h[1]. Brown, with 5 to 7 darker lines along sides; no canines; orbital tentacle small, finely fringed; nasal tentacle similar but smaller; dorsal XII, 23 or 24; anal II, 23 or 24.................................... 8. Females of *S. lineatus.*

h[2]. Without longitudinal black lines on sides.

i[1]. Reddish brown, with conspicuous rows of short blackish-brown bars and spots on sides, a row of spots on lower part of anal; often a blue dot or bar behind eye; simple tentacle on eye and a small divided nasal one; a minute canine below; dorsal XIII, 19 or 20; anal I, 19 or 20................................. 17. *S. interruptus.*

i[2]. Not as above; no canines.

j[1]. Dorsal free from caudal; whitish with 7 brown spots on side, each with 3 or more conspicuous black dots; a row of prominent black dots along lower part of side; minute simple tentacles on eye, nape, and nostril; dorsal XII, 19 or 20; anal II, 20.
18. *S. fowleri.*

j[2]. Dorsal attached to caudal.

k^1. Pectoral clear, with 3 rows minute brown dots; a row of red-brown spots above anal, and 2 to 4 rows posteriorly; dorsal and caudal clear, with 4 rows red-brown spots; males with a small canine; simple tentacle over eye; nasal tentacle bifid or trifid; dorsal XIII, 19 or 20; anal I, 19 to 21 .... 19. *S. deani.*

k^2. Pectoral not as above.

l^1. Brown with faint darker crossbands and many reddish to dark-brown dots or small spots all over body, dorsal, caudal, and pectorals; orbital and nape tentacles small; nasal tentacle very small, usually composed of 4 filaments; dorsal XIII, 19 to 21; anal I, 20 to 22.
11. Females of *S. edentulus.*

l^2. Dorsal XII or XIII, 20 to 22; anal I, 23 or 24, or III, 22; 7 double brown crossbars and 2 rows of brown dots on each half posteriorly; dorsal and caudal barred with brown and white, anal brown, all 3 fins white-margined; orbital tentacle equal to, or more than eye, tip and marginal filaments white or very pale.
16. Females of *S. aneitensis.*

1. SALARIAS FUSCUS Rüppell.

Salarias fuscus RÜPPELL, Neue Wirb. Fische (1935) 135, pl. 32, fig. 2; FOWLER, Copeia (June 18, 1918) 65; Acad. Nat. Sci. Phila. **79** (1927) 295.

Salarias holomelas GÜNTHER, Ann. & Mag. Nat. Hist. IV **10** (1872) 399; MEYER, An. Soc. Esp. Hist. Nat. Madrid **14** (1885) 31; HERRE, Fishes 1931 Philip. Exped. (1934) 97.

Dorsal 29 to 31; anal 19 or II, 18 or 19.

Body deep, often pot-bellied, much compressed; dorsal profile slanting rapidly downward from dorsal origin to caudal peduncle; anterior profile vertical or nearly so, usually projecting slightly beyond mouth. Depth 2.7 to 2.8, head 3.75 to 4 times in length. Caudal fin slender and elongate in small or medium-sized specimens, 2.5 to 2.8 times in length. Eye large, far forward, conspicuous, 3.75 to 4.25, snout 2.45 to 2.7 times in head. Margin of upper lip fimbriate; no canine teeth. Tentacles on eye and nape small, slender, simple, often difficult to find; nasal tentacles very small, simple or divided. Dorsal not notched, slightly or not at all attached to caudal. Last dorsal and anal rays often much elongated, extending nearly to end of caudal.

Dark brown to black; in the typical form the caudal is yellow, but every gradation occurs from all yellow through partly yellow to entirely black. Pectoral also yellow, with a circular black spot on upper part of base in typical *fuscus*, but it too varies in

color so that some individuals have the pectorals entirely dark brown.

I have examined 4 specimens from Jolo, 44 to 63 mm long, 10 from Sibutu, 47 to 67 mm long; and 12 from Sitankai, 34 to 60 mm long. Previously reported from Cebu. This blenny was first described from the Red Sea, but occurs abundantly as far east as the Pelew and Fiji Islands. I have never seen this blenny leave the water or cavort around on the rocks at low tide; it apparently always remains in the water.

2. SALARIAS CERAMENSIS Bleeker.

Salarias ceramensis BLEEKER, Nat. Tijdschr. Ned. Ind. **3** (1852) 701; HERRE, Fishes Herre 1931 Philip. Exped. (1934) 96.

Dorsal 29 or 30; anal I, 19 or 18. Depth 3.33, head 3.8 to 3.9, caudal 4.3 to 4.4 times in length. Anterior profile of head vertical; a broad palmately fringed tentacle on each side of nape, a narrower one on each eye, and a very small palmately fringed pair of nasal tentacles. No canines. Dorsal not notched, attached to caudal.

Alcoholic specimens brown, thickly sprinkled with blue-black dots; dorsal and caudal both cross-barred with rows of brown spots and with several rows of black dots along upper margin of dorsal and tip of tail. The anal may be sprinkled with dusky spots or clear brown.

Two specimens, 33 and 57 mm long, were examined from Sitankai. A specimen 112 mm long, from Singapore, has the tips of all the anal rays elongated, the anterior rays much elongated and almost entirely free.

A rare species, previously known only from Ceram, Buru, Amboyna, Misol, and Gebé, in the Dutch East Indies.

3. SALARIAS FASCIATUS (Bloch).

Blennius fasciatus BLOCH, Ichtyologie **2** (1786) 110, pl. 162, fig. 1.

Salarias fasciatus GÜNTHER, Cat. Fishes **3** (1861) 244; MEYER, An. Soc. Esp. Hist. Nat. Madrid **14** (1885) 31; PETERS, Monatsber. Akad. Wiss. Berlin (1868) 269; JORDAN and SEALE, Proc. U. S. Nat. Mus. **18** (1905) 799; EVERMANN and SEALE, Bull. Bur. Fish. **26** (1907) 104; JORDAN and RICHARDSON, Bull. Bur. Fish. **27** (1908) 284; FOWLER and BEAN, Proc. U. S. Nat. Mus. **62** (1923) 72; FOWLER, Proc. Acad. Nat. Sci. Phila. **79** (1927) 295; HERRE, Journal Pan Pac. Res. Instit. **8** (1933) 11; Fishes Philip. Exped. 1931 (1934) 97.

Dorsal XII, 19 or 20; anal I, 19 or 20. Depth 3.6 to 4, head 4.1 to 4.3 times in length. Eye 3 to 3.4 times in head. A bifid or trifid tentacle over each eye, a small bifid nasal tentacle, and

a broad fringed one on each side of nape. No canines. Undivided dorsal attached to caudal fin; anterior anal rays more or less detached, with elongate tips.

This large, heavy-bodied rock skipper is common in tide pools on rocky coasts, and, as shown by the list of citations above, has been collected many times in Philippine waters. When disturbed, it is one of the first fishes to leave, leaping over obstacles and climbing rocks with great speed; the very large individuals nearly always depart at the first hint of danger, so that they are seldom caught.

In life more or less violet-brown to bluish, with 6 to 8 broad brown bands across dorsal and body; between these bands, especially on lower part of body, on pectoral base, and on head sometimes, are sky-blue circular spots; on upper part of anterior half of body are many blue-black dots which pass into blue-black along middle of body; on dorsal two or three rows of very pale or bluish spots separated by broken upper ends of crossbars.

Alcoholic specimens brown, rarely bluish brown, with 6 to 8 broad darker-brown crossbands which extend on lower half of dorsal fin, breaking up into two bars and then fine lines on upper half. The blue-black dots and lines are as in life. Large yellowish or whitish circular spots, often with a central dark dot, usually covering pectoral base and under surface of body and head, and up to level of pectoral base. Dorsal as in life, but darker; pectoral and caudal pale, cross-barred by several rows of dark-brown or black spots; anal pale to dark brown, with two rows of dark-brown dots, tips of rays usually white.

This blenny, called *palu* at Cagayancillo, is found on all Philippine coasts, and is one of the easiest of our rock skippers to recognize. It is entirely unlike any others, so that it is never confused with the rest of the group. I have examined Philippine specimens ranging from 20 to 106 mm in length, from the following localities: Alabat Island, 1; Bacon, Sorsogon, 1; Bais, Oriental Negros Province, 6; Cabalian, Leyte, 2; Calapan, Mindoro, 2; Cebu, Cebu, 4; Dumaguete, Oriental Negros Province, 12; Iba, Zambales Province, 1; Nasugbu, Batangas Province, 2; Polillo, 1; Punta Flecha, Zamboanga Province, 4; Sibutu, 4; Sitankai, 18; Southern Negros, 1.

I have also examined the following specimens, ranging from 25 to 125 mm in length: Ishigaki, Riukiu Islands, 1; Taruna, Sangir Island, 3; Singapore, 5; Pelew Islands, 5; Nukulau, Fiji, 4; Ovalau, Fiji, 3; Suva, Fiji, 4; Apia, Samoa, 10. Two of the

Singapore specimens are much larger than any seen from the Philippines. These big specimens are females, the males never reaching much more than 75 mm.

This species ranges throughout Polynesia and westward to the Red Sea and the East Coast of Africa.

4. SALARIAS NITIDUS Günther.

Salarias nitidus GÜNTHER, Cat. Fishes 3 (1861) 243; Fische der Südsee 2 (1876) 200, pl. 113, fig. F (Description *pro parte*; not fig. G, which is *S. belemnites*); HERRE, Fishes Herre 1931 Philip. Exped. (1934) 97.

Salarias alboguttatus HERRE, Fishes Herre 1931 Philip. Exped. (1934) 96 (not of Kner).

Dorsal XII or XIII, 18 or 19 to 22; anal II, 20 to 22 or I, 23. Depth 6.9 to 7.3, head 5 to 5.3 times in length. Minute simple orbital and nasal tentacles, and a pair of similar tentacles on nape. Very small canines in lower jaw, but these may be absent. Dorsal free from caudal.

Alcoholic specimens gray to grayish brown, with 7 broad brown crossbands on upper two-thirds of body and extending on dorsal fin; sides of head sprinkled with pearly white spots, 2 or 3 rows of elongate brown-edged white spots on sides of body. Dorsal more or less reddish brown, spotted where crossed by dark bands extending up from trunk, and with 3 or 4 rows of white spots; anal clear, with a submarginal row of white spots and a dark-brown margin; caudal with cross rows of white spots, and a few dark specks, with dark-brown margins.

I have examined 17 specimens from Dumaguete, Oriental Negros Province, 22 to 37 mm long.

Salarias alboguttatus Kner, which resembles the above species very much, differs by having a large violet or violet-brown spot on each side of the throat.

Salarias nitidus is only known positively from the China Sea and the Philippines. The fish reported from Samoa as *S. nitidus* by Günther is *Salarias belemnites* deVis., which is widespread in Polynesia.

5. SALARIAS COLEI Herre.

Salarias colei HERRE, Fishes Herre 1931 Philip. Exped. (1934) 96.

Dorsal XV, 19; anal II, 20.

Depth 5.2 to 5.25, head 4.25 to 4.35, caudal 5 or 4.5 times in length. Eye 3.66 to 3.9, snout 2.6, least depth of caudal peduncle 2.3 times in head.

Body elongate, compressed; breadth of head equal to its depth; maxillary extending beneath hind margin of eye. On eye a stout, flat, marginally fimbriate tentacle, its length two-thirds that of eye; a fringed tentacle on anterior nostril; on nape a rounded crest. Dorsal deeply notched, free from caudal.

Alcoholic specimens uniform light brown, with 8 broad dark-brown crossbars, which divide below middle of side, and a dark crossband at caudal base. Sides of head sprinkled with many small, brown spots, or almost uniform in color. Dorsal mottled, or streaked with dusky lines running diagonally upward and backward; anal uniformly dusky, dorsal and anal rays tipped with white; caudal light brown to clear.

The type, 57 mm long, and one paratype, 50 mm long, are from Culion. No other specimens have been collected.

6. SALARIAS PERIOPHTHALMUS Cuvier and Valenciennes.

Salarias periophthalmus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 311, pl. 328; PETERS, Monatsber. Akad. Wiss. Berlin (1868) 269; HERRE, Journ. Pan Pac. Res. Inst. 8 (1933) 11; Fishes Herre Philip. Exped. 1931 (1934) 97.

Salarias deani JORDAN and SEALE, Bull. Bur. Fish. 27 (1908) 284.

Dorsal XII, 20 or 21; anal I or II, 20 or 21.

Very elongate, slender, strongly compressed. Depth 5 to 5.4, head 4.4 to 4.6, caudal 4.25 to 4.8, and pectoral 6 times in length. Eye 4, snout 3.1, least depth of caudal peduncle 2.25 times in head. Mouth inferior, convex profile bulging opposite eyes which are very far forward, maxillary extending well behind eye. Both sexes with a small curved canine on each side of lower jaw. Females with a small simple orbital tentacle; males with a longer one, equal to or more than eye, and a low median crest on top of head.

In life roseate, with 5 to 7 violet or violet-brown wide crossbars, which are violet-red and divided on lower part of body; along sides two rows of widely spaced short pearly blue bars which form a highly characteristic feature of this easily recognized species. Males with a pearly blue circular spot on opercle. Females with one or two pearly blue spots behind eye and a similar short bar below it. Sometimes males with blue spots behind eye.

Alcoholic specimens mottled leaden and brown or very dark brown, crossbands often dim or disappearing. Pearly blue bars and spots may retain their color, but more often blacken and sometimes disappear; careful examination will reveal some or

all of them, even when they seem to be absent; they are usually margined with black. Dorsal brown, with a white margin, and several darker lines or rows of spots running upward and backward; anal brown, with a dusky marginal band; caudal brown, its upper margin white, its basal portion with cross rows of white dots, and longitudinal white lines on membranes; tip may be white.

This is one of the most agile of the rock skippers, as well as one of the easiest to recognize. The coloration of preserved specimens is subject to very great variation, but the rows of pearly blue bars will always ensure identification. Females reach a length of 150 mm, but I have been unable to capture any such large and exceedingly active specimens.

I have examined the following Philippine specimens: Fifty-four from Nasugbu, Batangas Province, 22 to 51 mm long; 44 from Dumaguete, Oriental Negros Province, 15 to 38 mm long; 3 from Currimao, Ilocos Norte Province, 45 to 66 mm long; 9 from Culion, 36 to 55 mm long; 1 from Punta Flecha, Zamboanga Province, 34 mm long; 1 from Calayan, 60 mm long. The specimen from Calayan (?) *Salarias deani* Jordan and Seale in the citation above, is a male of *S. periophthalmus*.

The Stanford Museum also contains a specimen, 60 mm long, from Nukulau, Fiji; 4 specimens, 28 to 88 mm long, from Apia, Samoa; 12 specimens, 16 to 42 mm long, from Wala Island, New Hebrides; 1 specimen, 45 mm long, from Waigiu; and 1 specimen, 90 mm long, from Durban, Natal, South Africa.

SALARIAS PERIOPHTHALMUS var. VISAYANUS Herre.

Salarias periophthalmus var. *visayanus* HERRE, Fishes of the Herre 1931 Philip. Exped. (1934) 97, 98.

This well-marked variety is distinguished at once from the typical form by the presence of 4 to 8 longitudinal brown lines along each side; these lines are of variable length and irregular course, but usually extend from near the tip of the pectoral to above the middle of the anal. In alcohol they often partially disappear, and sometimes seem to vanish altogether.

The body and head are as in the typical form. In alcohol the lower half of the dorsal is pale to whitish brown, the upper half darker brown, with a conspicuous white margin; on all but the anterior part the dorsal is marked by widely spaced dark-brown lines running upward and backward. The caudal is cross-barred by white dots, its tip broadly white or whitish.

Abundant at Dumaguete, Oriental Negros Province, and at Culion, and no doubt all through the central and southern Philip-

pines. The type is 66 mm long, and 17 paratypes from Dumaguete, Oriental Negros Province, and 15 paratypes from Culion range down to a length of 20 mm. I also collected 4 specimens at Mombasa, East Africa, 34 to 64 mm long.

7. **SALARIAS CAUDOLINEATUS** Günther.

Salarias caudolineatus GÜNTHER, Fische der Südsee 2 (1876) 209, pl. 116, fig. F; HERRE, Journ. Pan Pac. Res. Inst. 8 (1933) 11; Fishes Herre Philip. Exped. 1931 (1934) 96.

Dorsal XIII, 20 to 23; anal I or II, 20 to 24.

Body elongate and compressed, depth 5 to 5.7, head 4 to 4.9, caudal 4.6 to 5 times in length. Eye 3.4 to 3.8, snout 2.8 to 3 times in head. Dorsal deeply notched, very slightly attached to caudal. Males usually with a large to very large median crest, but this is a highly variable character. Some specimens 25 to 30 mm long have an extravagantly large crest, while some males of 50 mm have a crest that is little more than a slight ridge. Females apparently lack the crest, though some individuals that seem to be females have a very small one. The mouth parts of many specimens from the Philippines, Polynesia, and the east coast of Africa show no canines in the lower jaw, except in 9 specimens, 16 to 50 mm long, which I collected at Hog Harbor, Espiritu Santo Island, in the New Hebrides. Günther and Fowler both state canines are present but they are evidently rarely developed. The orbital tentacle is variable with sex and age. It is often slender, pointed, and shorter than the eye, but may be much longer; males often have it with fibrillose margins, and it may become broad with long marginal fibrils. Upper lip crenulate.

Alcoholic specimens vary from pale gray or almost white to reddish brown or brown, with 6 to 8 broad darker-brown double crossbars over the back and down the sides; often these are reduced to dark-brown or blackish spots or bars beneath the dorsal and on its basal portion. On each side of the body are from 5 to 7 longitudinal black or very dark-brown lines, which break up posteriorly into dashes and dots. The dorsal is white or colorless, with black or brown dots or bars or with blackish lines running upward or backward, or the hind half may have 5 to 8 fine, wavy, longitudinal, reddish-brown lines. The anal is white or pale, with a basal row of dark-brown dots, or whitish with a submarginal dusky band and white tips on the pointed rays in females, or in males the entire outer portion, including the tips of the rays, may be black or blackish. The caudal is barred by numerous rows of black dots, the tip pale or whitish.

I have examined Philippine specimens as follows: One from Calapan, Mindoro, 40 mm; 33 from Nasugbu, Batangas Province, 15 to 61 mm; 22 from Dumaguete, Oriental Negros Province, 21 to 67 mm; and 1 from the South Coast of Cotabato Province, Mindanao, 65 mm long. In addition, I collected 3 specimens, 37 to 53 mm long, at Mombasa, East Africa; 2 at Waigiu, 43 to 48 mm long; a female, distended with eggs, at Malo Island, New Hebrides, 53 mm long; 1, 39 mm long, from Vila, Efate Island, New Hebrides; 10, from 40 to 86 mm long, from Wala Island, New Hebrides; and 2, from 52 to 72 mm long, from Ovalau, Fiji. This handsome rock skipper occurs all over the Indo-Pacific region.

8. SALARIAS LINEATUS Cuvier and Valenciennes.

Salarias lineatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **11** (1836) 314; HERRE, Journ. Pan Pac. Res. Inst. **8** (1933) 11; Fishes Herre Philip. Exped. 1931 (1934) 97.

Dorsal XII, 23 or 24; anal II, 23 or 24. Depth 5 to 5.3, head 4.5 to 4.9, caudal 5.65 to 5.5 times in length. Eye 3.8, snout 2.9 times in head. Body slender, elongate, compressed; anterior profile of broadly convex head nearly vertical. A small, finely fringed orbital tentacle and a smaller one on the anterior nostril. No canines; dorsal fin deeply notched. Males have a low median crest on head, which is lacking in females.

Alcoholic specimens vary from grayish brown and reddish or purplish brown to leaden, with 6 short black or dark-brown double crossbars over back; alternating with these are 6 pairs of dark-brown double bars on lower two-thirds of body. Along each side, from head to caudal base, 4 to 6 black lines, some of which may be wavy and run together, or may not extend all the way. Dorsal varying from clear or whitish to pale brown, with 4 to 8 dark-brown lines running upward and backward, those along top of second dorsal nearly horizontal and very close together, leaving a whitish band along middle of second dorsal. Anal very pale to light brown, with a dark-brown or blackish margin. Caudal whitish basally with remainder purplish brown, or entirely pale to dark brown. Philippine specimens have blackish vertical lines on snout and sides of head.

Five excellent examples, 40 to 77 mm long, were obtained at Dumaguete, Oriental Negros Province, and 3, 49 to 62 mm long, in wretched condition, were received from Nasugbu, Batangas Province. In addition I have examined the following: 2 from

the Sembilan Islands, on the west coast of the Malay Peninsula, 109 and 112 mm long; 1 from Lembeh Strait, Celebes, 48 mm long; 2 from Ovalau, Fiji, 29 and 52 mm long; and 3 from Pago Pago, Samoa, 58 to 85 mm long. This species is found from the Andaman Islands eastward throughout Polynesia.

9. SALARIAS OORTI Bleeker.

Salarias oorti BLEEKER, Nat. Tijd. Ned. Ind. 1 (1850) 257, fig. 15; HERRE, Journ. Pan Pac. Res. Inst. 8 (1933) 11; Fishes Herre Philip. Exped. 1931 (1934) 97.

Dorsal XIII, 19 to 21; anal I or II, 19 or 20, or I, 21 or 22; depth 5.3 to 5.8, head 4.65 to 4.8, caudal 4.45 to 4.7 times in length; eye 3.75 to 3.9, snout 3 to 3.2 times in head. Interorbital space concave, eyes very far forward, anterior profile vertical or forehead projecting beyond mouth; maxillary extending beneath hind margin of eye; my specimens have no canines, but Bleeker and Günther state that adults have small canines in the lower jaw. A rather large rounded median crest on top of head; orbital tentacle two-thirds as long as eye and simple, or very small and simple, or small and fringed.

Roseate, with many violet crossbands, often arranged in pairs, and broader than interspaces, but breaking up into irregular lines on last third of body. First part of dorsal violet or reddish, with four diagonal or longitudinal wavy blue stripes; hind part violet or rose, with or without a broad yellow or pale band along middle, and 5 or 6 diagonally lengthwise dark-edged blue stripes on upper half. Anal darker than body, caudal paler, with outer third reticulated with blue lines enclosing white spots. Alcoholic specimens roseate and violet, turning to violet-brown and brown, and blue lines on fins becoming dark brown.

A specimen, 68 mm long, from Atimonan, Tayabas Province; 1, 56 mm long, from Calapan, Mindoro; 2, 56 mm long, from Dumaguete, Oriental Negros Province; 1, 58 mm long, from Iba, Zambales Province; and 1, 71 mm long, from Mariveles, Bataan Province, have been examined. This handsome rock skipper is known elsewhere from Sumatra, Java, and the Moluccas, and has also been reported from Fiji and Zanzibar.

10. SALARIAS BILINEATUS Peters.

Salarias bilineatus PETERS, Monatsber. Akad. Wiss. Berlin (1868) 269; HERRE, Fishes Philip. Exped. 1931 (1934) 96 (in part; Culion specimens only).

Dorsal XII, 15 to 17, or XIII, 17 or 18; anal I or II, 16 to 18. Depth 5, head 3.9 to 4, rounded caudal 4 to 4.6 times in length.

Eye 4 to 4.5, snout about 3 times in head. Anterior profile of head rounded, projecting, eyes very high up and projecting above dorsal profile.

Males with a median crest on head, a small orbital tentacle, simple or with fringed margins, a minute one on nape, and a minute fringed nasal tentacle. There may be a minute canine on each side of lower jaws. Females have no crest, a simple or fringed tentacle on eye only, and no canines.

Alcoholic specimens gray, densely punctate with brown, or fading to uniform slate, with 6 double dark-brown crossbands; on sides between dark bands two rows of white dots, or numerous white dots arranged in backward curving vertical rows, with 4 to 6 dots in a row, with smaller blue dots on sides of head. All dots may become brown in preserved specimens. Three dark bands on snout and lower part of preopercle and extending on throat, with white bands or spots between them on throat; behind eye a black bar. Dorsal clear, with a characteristic black spot at top between first and second spines; about 9 blackish bars running up and back on second half of dorsal. Anal clear or with a dark submarginal band; caudal with a blackish spot at its base.

Specimens were examined as follows: Seven from Culion, 30 to 45 mm long; 4 from Nasugbu, Batangas Province, 25 to 27 mm long. Peters had a single specimen, taken on a coral reef east of Lauang, Samar. This rock skipper seems to be confined to the Philippines.

The three specimens from Nasugbu placed under *S. bilineatus* in Fishes of the Herre 1931 Philippine Expedition (1934) 96, are really *Salarias frenatus*.

11. SALARIAS EDENTULUS (Bloch & Schneider).

Blennius edentulus BLOCH & SCHNEIDER, Syst. Ich. (1801) 172.

Salarias edentulus GÜNTHER, Fische der Südsee 2 (1877) 206, pl. 117, fig. *A*, showing the female; JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 789; JORDAN and RICHARDSON, Bull. Bur. Fish. 27 (1908) 284; HERRE, Journ. Pan Pac. Res. Inst. 8 (1933) 11; Fishes Philip. Exped. 1931 (1934) 97.

Salarias rivulatus JORDAN and RICHARDSON, Bull. Bur. Fish. 27 (1908) 284.

Salarias quadricornis GÜNTHER, Fische der Südsee 2 (1877) 209, pl. 117, fig. *B*, showing the male of *S. edentulus*.

Dorsal XIII (rarely XIV) 19 to 21; anal usually I (rarely II), with 20 to 22 rays, exceptionally 23 or 24. A female 65 mm long has the depth 3.1, the head 4 times in the length. Eye 3.7,

snout 2.35 times in head. A female 84 mm long, ready to spawn, has the depth equal to the head, 4 times in the length. Eye 4, snout 2.66 times in head. In males 75 to 78 mm long, depth equal to head, 4.3 to 4.7 times in length. Eye 3.8 to nearly 4, snout 2.3 times in head.

Both sexes have a simple orbital tentacle, shorter than the eye, and a pair of small simple tentacles on the nape; one or both of these last are often absent; the front nostril has a very small tentacle which is usually divided into 4 filaments. The high dorsal fin is deeply divided and is broadly united with the caudal fin. The anterior anal rays have more or less elongate and swollen tips.

The sexes are unlike and have been described as different species. *S. edentulus* of many authors is the female, and *S. quadricornis* is the male. An important male character is the presence of a high median occipital crest; but at Makatea Island, one of the Tuamotu Archipelago, I secured females varying from those with the typical smooth occiput to some with a moderately high crest.

Typical females are like Günther's figure, cited above. In alcohol the brown body is faintly cross-barred by darker bands, and thickly strewn with many reddish to dark-brown spots. The dorsal, caudal, and pectorals are covered with smaller similar spots. Anal with 2 or 3 rows of dark-brown spots, rays with white tips.

Males darker, becoming uniform dark brown, or brown with darker crossbars, or black with pale or whitish crossbars or narrow whitish cross lines. The anal has two lengthwise rows or lines of bluish spots, which often disappear in alcohol; tips of rays white. The forward half of the dorsal has longitudinal, the second half diagonal, rows of pale-yellowish or whitish spots and lines, which usually disappear in alcohol. There is a diagonal dark bar behind the eye, which often disappears.

This is by far the commonest of all Philippine blennies. Preserved specimens are subject to great variation in color, and often all markings entirely disappear. Examination of a large series will enable one to place such puzzling specimens. The following Philippine specimens were studied, their lengths varying from 16 to 106 mm: Cabalian, Leyte, 1; Calapan, Mindoro, 2; Calayan Island, 4; South Coast of Cotabato Province, 1; Dumaguete, Oriental Negros Province, 81; Guindulman, Bohol Province, 1; Iba, Zambales Province, 1; Jolo, Sulu Province, 1;

Kolambugan, Lanao Province, 1; Nasugbu, Batangas Province, 46; Odiongan, Tablas, 4; Sitankai, 2.

I have also examined specimens as follows: Hoihow, Hainan Island, 1 specimen, 51 mm long; Pu Taw Island, Chusan Archipelago, China, 2, each 42 mm long; Pelew Islands, 3 specimens, 32 to 55 mm long; Tinian Island, Marianas, 2 specimens, 60 and 75 mm; Lembeh Strait, Celebes, 6, from 40 to 67 mm; Waigui, 3, from 47 to 61 mm long; Lord Howe Island, 2 very fine specimens, 61 and 101 mm long; from the New Hebrides, 25 at Wala Island, 25 to 63 mm long; 4 at Malo Island, 40 to 51 mm long; and 72 at Hog Harbor, Espiritu Santo Island, 13 to 80 mm long; from Ovalau Island, Fiji, 4, from 30 to 58 mm long; 13 from Pago Pago, Samoa, 23 to 77 mm long, 46 elegant specimens from Makatea, Tuamotu Archipelago, 33 to 104 mm long; from the Marquesas Islands, 54 taken at Atuona, Hiva Oa Island, from 26 to 78 mm long, and 38 from Nuka Hiva Island, 13 to 84 mm long. I also collected a specimen 45 mm long at Mombasa, East Africa.

12. SALARIAS ZAMBOANGÆ Evermann and Seale.

Salarias zamboangæ EVERMANN and SEALE, Proc. U. S. Nat. Mus. 31 (1907) 512, fig. 4; HERRE, Journ. Pan Pac. Res. Inst. 8 (1933) 11; Fishes 1931 Philip. Exped. (1934) 98.

Dorsal XII or XIII, 20 to 22; anal I, 23 or 24, or II, 21 to 24, or III, 22.

Caudal fin equal to depth, 4.75 to 5.25 times in length, head 4.2 to 4.5 times. Eye 4.25 to 4.3, snout 3 times in head.

Body slender, compressed, head rounded, with vertical anterior profile, eyes prominent, projecting upward and outward. Males with a medium-sized to large crest on midline of head: orbital tentacle usually with a white tip and white-tipped marginal filaments, equal to or longer than eye; nasal tentacle small, bifid or trifid; no tentacles on nape, no canines in lower jaw. Females without skinny crest on head. Dorsal fin of moderate height, not very deeply incised, attached to caudal, its last rays projecting to middle of caudal when depressed.

Alcoholic specimens whitish or bluish-brown to light brown, with 7 brown double crossbars over back and down sides, and usually two rows of small, round, brown spots or dots on lower part of posterior part of body. First dorsal marked by wavy longitudinal or downward curving dark lines, often with a blackish spot at top between first and second and second and third spines; posterior part marked by several diagonal rows

of dark spots, often with a clear band along middle; there may be a dark submarginal band, made up of fine dark lines; dorsal, caudal, and anal all white-margined. Anal with a dusky submarginal band, rest of fin colorless to brown; caudal barred by several rows of dark-brown spots.

Specimens have been examined as follows: Five from Nasugbu, Batangas Province, 38 to 54 mm long; 3 from Calapan, Mindoro, 44 to 47 mm long; 2 specimens from Bais, Oriental Negros Province, 53 mm long; 39 from Dumaguete, Oriental Negros Province, 23 to 63 mm long; a female specimen, from Lembeh Strait, Celebes, 57 mm long. Originally described from 3 specimens, 51 to 69 mm long, taken at Zamboanga Province.

18. SALARIAS FRENATUS Cuvier and Valenciennes.

Salarias frenatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. **11** (1836) 342; GÜNTHER, Cat. Fishes **3** (1861) 246; DAY, Fishes of India (1878–1888) 335, pl. 70, fig. 9; SAUVAGE, Poissons de Madagascar (1891) 388, pl. 41*A*, fig. 5.

Salarias bilineatus HERRE, Fishes 1931 Philip. Exped. (1934) 96, *pro parte;* 3 specimens from Nasugbu.

Dorsal XII or XIII, 15 to 17; anal I, 17 to 19 or II, 16 or 17. Depth 5.1 to 5.2, head 4.4 to 4.6, caudal 4.25 to 4.4 times in length; eye prominent, 3.9 to 4, vertical snout 2.5 to 2.75 times in head. Orbital tentacle broad, pointed, equal to eye, with fimbriate edges; no tentacle at nape and a very small simple tentacle on nostril. Largest specimens with a slight suggestion of a nuchal crest. Upper lip denticulated. Some specimens, most likely males, have a very small canine in the lower jaw. Dorsal deeply incised, free from caudal, anterior portion lower than rear half.

Alcoholic specimens varying from slate-blue, crossed by 8 or 10 darker-blue bands, to bluish or brownish-gray with brown or bluish-brown crossbands; dark lines from eye over snout, preopercle, opercle, and across under side of head. In life pearly blue or white bands with dark margins on head; these bands fading to brown like rest of head, leaving their margins as dark lines mentioned above. First dorsal clear to dusky, often with a blackish spot at top between first and second spines, second dorsal with diagonal dark-brown bands; caudal clear to dusky, or with cross rows of brown spots; anal clear, or with a submarginal row of brown spots on membranes; pectoral clear above, brown on lower half.

Thirty-two specimens, 22 to 62 mm long, were taken at Nasugbu, Batangas Province. My specimens agree in all essentials with Day's and Sauvage's figures. The original description erred in saying the dorsal is not divided. Day's figure was made from one of the types, and, as he states, the second dorsal is "separated by a well marked notch." Both Day and Sauvage have improved on the original description, but Sauvage is the only one who mentions the crenulated upper lip.

Salarias crenulatus M. Weber is very close to *S. frenatus*, but I cannot make my specimens agree with either Weber's description or figure. Originally described from India, and later from Madagascar, this blenny is reported for the first time from the Philippines. I do not doubt its occurrence in many other localities over a large part of the Philippines, but it has been overlooked by collectors.

14. SALARIAS MARMORATUS (Bennett).

Blennius marmoratus BENNETT, Zool. Journ. 4 (1828) 35.
Salarias marmoratus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 11 (1836) 305; HERRE, Fishes 1931 Philip. Exped. (1934) 97.

Dorsal XII or XIII, 14 to 16; anal I or II, 16 or 17.

Depth 4.8 to 5.2, head 3.8 to 4.3 times in length; broad, somewhat obliquely truncate caudal equal to head. Eye 3.5 to 4.2, snout 2.4 to 2.6 times in head.

Head broad, with rounded profile and nearly vertical snout; eyes projecting, very high up and far forward; orbital tentacle marginally fringed and equal to, or nearly equal to, eye; a pair of very small simple tentacles at nape; nasal tentacles very short, broad, palmately fringed. Upper lip rather coarsely crenulate.

Alcoholic specimens pale tan to purplish brown, often gray or white on upper side, with 5 or 6 dark-brown double crossbands on sides, alternating with an equal number of short dark-brown double bars on back; lateral bars may break down into spots which often are clustered along the middle of the side; a blackish-brown elongate vertical bar or black spot hebind eye, a blackish blotch above pectoral base. Head often thickly sprinkled with white or bluish dots, spotted and mottled anteriorly and underneath with pearly or bluish. Fins pale, dorsal and caudal heavily marked with crossrows of brown to black spots; anal with a submarginal dusky band, tips of rays pale or white.

I collected 8 specimens, 29 to 38 mm long, at Nasugbu, Batangas Province, and 3, 27 to 48 mm long, at Dumaguete, Oriental

Negros Province. Specimens were also obtained elsewhere, as follows: Waigiu, 1 specimen, 27 mm long; 3 from Nuka Hiva, Marquesas Islands, 36 to 56 mm long. I also examined 14 fine typical specimens from the Hawaiian Islands, from 50 to 88 mm long.

15. SALARIAS GUTTATUS Cuvier and Valenciennes.

Salarias guttatus CUVIER and VALENCIENNES, Hist Nat. Poiss. 11 (1836) 228; HERRE, Fishes Crane Pacif. Exped. Zoöl. Ser. Field Mus. Nat. Hist. 21 (1936) 409.

Salarias undecimalis JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 800, fig. 18; HERRE, Fishes 1931 Philip. Exped. (1934) 98.

Dorsal XI or XII, 17 or 18; anal I, 18 or 19.

Body moderately slender, laterally compressed on posterior half, anterior profile vertical; eyes very prominent, very high up and far forward, projecting beyond contour. Depth 4.4 to 4.8, head 4 to 4.1, caudal 4.1 to 4.5 times in length. Eye 3 to 3.2, snout 2.85 to 3 times in head.

Low dorsal deeply divided, not attached to caudal fin. Small simple tentacles present on eye, nape, and nostril. Head without crest, lower jaw without canines.

Alcoholic specimen varying from pale brown to reddish brown, with 6 or 7 pale or white double crossbands on sides of body, which are forked on the lower half of trunk; very often they break up into white dots on upper part; between them body color appears as an equal number of darker bands. On the upper half of body numerous short vertical violet to violet-black lines and dots, especially on forward half; usually a row of 15 to 20 black dots just below dorsal fin, often another row of larger black dots extending from above pectoral to caudal base, or black dots sprinkled sparingly on side. On lower end of pectoral base and just in front of it one or two large circular white or very pale-brown spots are very characteristic. Sides of head, pectoral base, and lower half of trunk more or less white-spotted. On each side of throat a dark purplish spot or ring. Dorsal and caudal colorless, cross-barred by rows of brown spots on rays; anal more or less dusky marginally, tips of rays much paler.

I have collected and examined the following: 2 from Nasugbu, Batangas Province, 24 and 35 mm long; 4 from Culion, 29 to 39 mm long; 19 from Bais, Oriental Negros Province, 22 to 35 mm long; 6 from Dumaguete, Oriental Negros Province, 25 to 34 mm long; 6 from Punta Flecha, Zamboanga Province, 21 to 32 mm long; and 13 from Sitankai, 29 to 48 mm long.

The Stanford Museum also contains two cotypes of *Salarias undecimalis*, 30 and 37 mm long, collected by Dr. Bashford Dean at Bais, Oriental Negros Province. Most of the specimens above were determined as *S. undecimalis*, but are unquestionably *Salarias guttatus*. They agree with typical specimens of *S. guttatus* which I collected in the New Hebrides. Two faded specimens from Singapore, 40 and 62 mm long, also belong here.

For many years this handsome rock skipper was known only from two small specimens collected at Vanikolo. It is now known from Singapore to Samoa, but is apparently rare everywhere except in the Philippines.

The three sets of simple tentacles, the number of fin rays, and the presence of the pale spots at the pectoral base, the purple spots on the throat, and the black dots along the body separate it from our other rock skippers. The figure given by Jordan and Seale is excellent.

16. **SALARIAS ANEITENSIS Günther.**

Salarias aneitensis GÜNTHER, Fische der Südsee 2 (1877) 205, pl. 118, fig. *A*.

Dorsal XIII, 15 to 17; anal II, 16 to 18.

Depth equal to head, 4.2 to 4.4 times in length. Rounded caudal shorter than head, 4.6 times in length. Eye 5.6, snout 2.33 times in head.

Robust, broad anteriorly, posterior two-thirds laterally compressed; snout rounded, anterior profile steep but not vertical, eyes not projecting or conspicuous. Orbital tentacle large, pointed, marginally fringed, a trifle longer than an eye diameter; on each side of nape a tiny tentacle, on nostril a short, broad, palmately fringed tentacle. A small canine on either side of lower jaw. Low dorsal deeply incised, free from caudal fin.

Alcoholic specimens dark-reddish-plum-colored, becoming paler to yellowish underneath, back and sides covered with many black dots which pass into lengthwise brown or black stripes on posterior half. Dorsal, caudal, and pectoral with crossrows of dark-brown spots on rays; on dorsal these forming wavy lines running upward and backward. Anal with two black longitudinal stripes, tips of rays pale or white.

Two fine examples, 88 and 117 mm long, were caught at Puerto Galera, Mindoro. They agree with Günther's figure in proportions and markings; as his description was made from a dried specimen the tentacles were not observed.

One of the largest rock skippers, reaching a length of more than 175 mm. It has hitherto been known only from Aneiteum, one of the New Hebrides, Apia, Samoa, and Niuafoou Island.

17. SALARIAS INTERRUPTUS Bleeker.

Salarias interruptus BLEEKER, Nat. Tijds. Ned. Ind. 3 (1857) 68.

Dorsal XIII, 19 or 20; anal I, 19 or 20.

In adults depth and caudal approximately equal, 5 to 5.6, head 4.2 to 4.5 times in length; in young specimens depth 6.5 to 6.75 times in standard length; eye 4 to 4.3 times, snout 3.5 times in head. Eyes very high up and far forward, interorbital concave; anterior profile vertical or forehead slightly projecting. A small, simple, orbital tentacle, and a small bifid or trifid nasal tentacle. No crest on head. A minute canine on each side of lower jaw. Dorsal deeply notched, not attached to caudal.

Alcoholic specimens warm reddish brown, with several rows of conspicuous short blackish-brown or black longitudinal bars and spots; dorsal and caudal clear, with 3 rows of black spots on forward part and 4 or 5 rows on hind portion of dorsal, and 5 or 6 crossrows on caudal. Anal with a row of black spots on lower part between rays, a broad submarginal dusky band, and a white margin. Large specimens have a blue dot or short bar behind the eye, and sometimes one below the eye.

Forty-eight examples from Nasugbu, Batangas Province, are 18 to 50 mm long, and 3 from Dumaguete, Oriental Negros Province, are 31 to 59 mm long.

This very handsome rock skipper is found in the East Indies and is said to occur as far eastward as Samoa.

18. SALARIAS FOWLERI Herre.

Salarias fowleri HERRE, Philip. Journ. Sci. 59 (1936) 364, pl. 2, fig. 7.

Dorsal XII, 19 or 20; anal II, 20. Minute simple nasal, orbital, and nape tentacles present, or any one or two pairs may be absent; no occipital crest, and no canines.

Depth 6 to 6.2, head 4.8 to 5.1, pectoral 4 to 4.4, ventral 7.75 to 8 times in length. Eye, snout, and least depth of caudal peduncle each 3 times in head. Body elongate, compressed, with bluntly rounded head, which is broader than deep; anterior profile nearly vertical, mouth slightly projecting, maxillary extending beneath posterior portion of prominent eye. Dorsal moderately notched, height 2, that of anal 3 times in head. Dorsal and anal free, not extending to caudal.

Alcoholic specimens whitish, with seven brown spots along middle of side, each spot containing three or more conspicuous black dots; between spots are dots and specks, and along lower side a row of prominent black dots; rather faint brown dorsal bands composed of minute dots opposite lateral spots; head and upper anterior half more or less covered with minute brown specks. Three or four rows of black dots on dorsal rays, intervening portions white, membrane clear; nine or ten black dots beneath anal, which is clear with a black submarginal band and a white margin; caudal with four crossbars.

Described from the type, 31 mm long, and 9 paratypes, 16 to 28 mm long, taken from a tide pool at Dumaguete, Oriental Negros Province. On my last visit to Dumaguete another specimen, 27 mm long, was taken.

Named for Henry W. Fowler, who has made large contributions to our knowledge of Philippine fishes.

19. SALARIAS DEANI Jordan and Seale.

Salarias deani JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 799, fig. 17; HERRE, Fishes 1931 Philip. Exped. (1934) 97.

Dorsal XIII, 19 or 20; anal I, 19 to 21.

Body elongate, depth varying with age, feeding, and sex; in most specimens from 49 to 56 mm long depth 5.3 to 5.6, but a specimen 46 mm long and stuffed with food has the depth 6 times or more in the length; others about the same length have the depth 6 times in length. Eye large, high up and far forward, $3\frac{2}{3}$ to 3.8, snout 2.7 to 2.9 times in head. Dorsal deeply divided, not attached to caudal fin. Orbital tentacle shorter than eye, usually pointed and slender, but may be broader with fimbriate margins; nasal tentacle bifid or trifid; no tentacles on nape and no crest on top of head. Anterior profile of head vertical or overhanging, angle of mouth behind eye.

Alcoholic specimens light brown, with 6 or more less evident dark-brown double crossbars; these often fading entirely, leaving only a row of red-brown spots above anal and two to four rows of reddish-brown spots on posterior fourth or fifth of body. Dorsal and caudal clear, with three or four rows of red-brown or very dark-brown spots on dorsal rays, and 4 or 5 crossrows on caudal. Anal pale brown, with a large brown spot on lower part of every other ray on last half of fin, and a more or less evident submarginal dark band; tips of rays white. Pectoral colorless, with 3 crossrows of brown dots, or sometimes of brown spots.

This species was described from a specimen obtained at Bais, Oriental Negros Province, by Dr. Bashford Dean. The Stanford Museum contains two specimens, 49 and 57 mm long, collected with the type by Doctor Dean. In addition I have collected and examined 5 specimens from Nasugbu, Batangas Province, 42 to 49 mm long; 8 from Dumaguete, Oriental Negros Province, 19 to 46 mm long; 4 from Opon, Mactan Island, 35 to 56 mm long; 2 from Jolo, 48 and 57 mm long; and 1 from Sitankai, 53 mm long.

Genus LEMBEICHTHYS Herre

Lembeichthys HERRE, Philip. Journ. Sci. 59 (1936) 283.

Dorsal 68 to 70; anal 50 to 55.

Body elongate, tapering, naked, with caudal separate from dorsal and anal; dorsal composed of flexible spines, its origin over opercle; origin of anal in anterior portion of body, length of anal more than twice that of head and trunk together; ventrals very small, composed of two rays, inserted beneath hind margin of opercle, distinctly in advance of pectoral. Head deeper and broader than body, without tentacles or barbels, snout blunt, mouth inferior; teeth in one row, fixed, different in the two jaws, those of the lower jaw with arrowlike tips; a large pair of posterior canines in lower jaw, as in *Petroscirtes*. Gill opening small, above upper angle of pectoral base.

Type species, *Lembeichthys celebesensis* Herre.

From *Pholidichthys* Bleeker, to which it is closely related, *Lembeichthys* differs in the dentition, and in having the caudal fin entirely free from the other fins.

LEMBEICHTHYS CELEBESENSIS Herre. Plate 5.

Lembeichthys celebesensis HERRE, Philip. Journ. Sci. 59 (1936) 283, pl. 1, fig. 3.

Dorsal 68 to 70; anal 50 to 55; caudal with 11 rays plus 2 accessory rays on both upper and lower margins.

Depth 15.7, head 7.85 to 8.46, caudal 11, pectoral 12.2 to 12.5 times in length; head and trunk together 2.4 to 2.9 times in tail, which is 70 to 74.5 per cent of the total.

Head broader and deeper than trunk or tail, with a broad, blunt, projecting snout; eye 3.33 to 3.6, snout 4.1 to 5.4 times in head; interorbital equal to eye; mouth inferior and rather large, extending beneath anterior portion of pupil; 20 or 22 flat incisorlike teeth in upper jaw, end tooth on each side pointed

and a little larger than the others; 22 teeth in lower jaw, their tips shaped like arrowheads; the two large curved canines in length equal to diameter of pupil.

First few dorsal spines low, those following highest, $2\frac{1}{3}$ in head, most of fin of nearly uniform height; anal 3.5 times in head. Pectoral pointed; caudal of one specimen forked but damaged; the other nearly truncate; the minute ventral is 7 times in head.

Alcoholic specimens pale tan, lower half sprinkled with reddish-brown specks, and with more or less silvery sheen on sides of head, trunk, tail, and yellow belly; five dark-brown spots on dorsal region beneath dorsal, first above anal origin; snout dusky, area between eyes and dorsal origin dark brown. Dorsal and anal pinkish brown, densely dotted with dark-brown specks, and with a black margin. Caudal with a large red-brown basal spot, rest of fin white; pectorals and ventrals also white.

Here described from the type and paratype, both 55 mm long, collected at Lembeh Strait, Celebes. The type is much bulkier than the paratype and has a longer head and trunk.

This singular blenny is included here because the type locality is so close to both Davao and the Sibutu Islands. Experience has shown that we may expect the marine fishes of the north end of Celebes to occur also in the Philippines as far north as Dumaguete, Cebu, and Samar. Probably a pelagic blenny, caught while fishing with an electric light. I do not doubt its occurrence in Philippine waters.

XIPHASIIDÆ

A family of eellike, naked blennies with the tail greatly elongated, and laterally compressed, and very long dorsal and anal, confluent with the caudal fin. Head short, eyes very large, lateral; teeth of uniform size, close together, with a pair of enormous posterior canines in lower jaw; behind these in upper jaw a pair of much smaller canines. Ventrals on throat, before gill opening, composed of three elongated and filamentous rays.

Strange looking and little-known fishes, perhaps of but a single wide-ranging species in the tropical Pacific and Indian Oceans. Several species have been described, and it is possible that two or three are valid. They are pelagic or semipelagic, occurring also on reefs off shore or in deep channels. The extraordinary canines of these fishes have excited considerable curiosity.

Genus XIPHASIA Swainson

Xiphasia SWAINSON, Nat. Hist. 2 (1839) 259.

Tail four to six times as long as head and trunk together, or even longer, and much compressed laterally, especially posteriorly; head and trunk more rounded, but also compressed, the whole body very low. Fin rays all flexible, dorsal origin over or before eyes. Gill openings small, restricted, before upper end of pectoral base and above. Branchiostegals 6.

XIPHASIA SETIFER Swainson.

Xiphasia setifer SWAINSON, Nat. Hist. 2 (1938) 259; DAY, Fishes of India (1878–1888) 337, pl. 73, fig. 1; TANAKA, Journ. Coll. Sci. Imp. Univ. Tokyo Art. 7 23 (1908) 49, pl. 4, fig. 1; HERRE, Philip. Journ. Sci. 31 (1926) 224, text fig. 1 and pl. 1.

Dorsal 123 to 126; anal 110 to 114.

Depth 33 to 36 times in length, greatest depth at back end of head and immediately behind it; Tanaka gives the depth as 38 to 47.5, but evidently measured the depth farther back. Body very elongate, eellike, laterally compressed on tail especially, which becomes ribbonlike and forms from 82 to 85 per cent of the total length. Head large, nearly as long as trunk, boldly convex anteriorly, 13 to 15 times in length, trunk 12 to 12.75 in length. Eye rather large, circular, 3.8 to 4.3 times in head. Dorsal beginning on interorbital before eyes. Caudal with the two central rays greatly elongated and hairlike, about 10 times in length.

In life bright yellow, or sometimes grayish yellow, with 28 broad dusky-brown crossbands on dorsal and body, first crossband just behind head; dorsal and anal yellow, with broad marginal dusky band, or dorsal largely dusky; ventrals and pectorals yellow, the latter with longitudinal flesh-colored lines.

In alcoholic specimens the yellow fades, and the fins become largely brown or blackish, with the body crossed by vague, wide, pale, and blackish bars.

I have seen but one Philippine specimen, 503 mm long, obtained by Dr. J. W. Chapman, of Silliman University, Dumaguete. In addition I have collected 2 specimens, 195 and 212 mm long, at Lembeh Strait, Celebes, and have examined a specimen 370 mm long from Sagami Sea, Japan. This fish reaches a length of two-thirds of a meter, and occurs from Natal, South Africa, to Japan, and eastward in the Pacific to the New Hebrides.

CONGROGADIDÆ

Ventral fins absent, except in one form which has them jugular, and reduced to one or two filamentous rays. Body elongate, compressed, covered with very small scales, vertical fins united or caudal free. Gill membranes may be united and free from isthmus, or may be joined to it. Mouth protractile, with strongly developed lips; jaws with a single row of small conical or compressed teeth.

The family comprises reef fishes of shallow coastal waters, distributed from the Red Seas to the Philippines and Australia. The species are few, divided among 5 genera. They are rarely eaten, and are of no commercial value.

Key to the Philippine genera of Congrogadidæ.

a^1. No spine in front of dorsal origin .... *Congrogadus.*
a^2. A small sharp spine in front of dorsal origin .... *Congrogadoides.*

Genus CONGROGADUS Günther

Congrogadus GÜNTHER, Cat. Fishes 4 (1862) 388.

Body compressed, elongate, eellike, covered with very small scales; dorsal and anal both long and united with caudal. Gill openings rather wide, gill membranes united and forming a free fold across isthmus. Mouth wide, with a projecting and prominent lower jaw. Four gills, with a slit behind fourth; pseudobranchiæ well-developed. Air bladder and pyloric appendages lacking. Vent far from head.

CONGROGADUS SUBDUCENS (Richardson).

Machærium subducens RICHARDSON, Ann. & Mag. Nat. Hist. 12 (1843) 175, pl. 6; Voy. Erebus & Terror Fishes (1844–1848) 72, pl. 44, figs. 1–6.

Congrogadus subducens GÜNTHER, Cat. Fishes 4 (1862) 388; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 285; HERRE, Fishes 1931 Philip. Exped. (1934) 100.

Machærium nebulatum BLEEKER, Nat. Tijds. Ned. Ind. 3 (1852) 76.

This fish is known as *batad* at Cuyo.

Dorsal 71 to 76; anal 60 to 65. Scales in a longitudinal series 245 to 260; from about 35 to 40 teeth on each side of both upper and lower jaws, usually 38 to 40 in adults; lateral line ending under tenth to twelfth dorsal ray and with from 50 to 56 tubules.

Depth 8.65 to 10, head 6.5 to 6.9 times in length. Eye 6.4 to 6.7 times in head, and 1.7 to 2 times in snout. Maxillary extending to hind margin of eye or beyond, 2.1 to 2.2 times in

head; snout pointed, 3.33 to 3.8, pectoral 2.75 to 2.85 times in head.

Body elongate, strongly compressed, head sloping forward, snout keeled and steeply descending, lower jaw strongly projecting. Greatest depth may be about middle of trunk, but is usually back on tail, at least a head length behind vent. Angle of mouth beneath anterior part or middle of eye.

In life color highly variable. Specimens taken at the same time and place may be grass green, maroon, brownish red, dark brown, to pale yellowish; the color may be almost uniform, but is usually irregularly spotted with darker spots of various sizes, and sprinkled with pearly spots which may form reticulations and crossbands; under side of head and trunk usually much paler, with large pearl-colored or red spots on head, throat, and belly. Dorsal and anal with membranes uniformly dark, or one to several rows of dark spots on membrane; sometimes conspicuous dark spots along base of vertical fins. A dark spot often present on opercle; it may be a definite ocellus, but is often absent.

Alcoholic specimens usually darkening, green, red, and maroon disappearing; pearly spots and markings disappearing or else turning white, and specimens tending to become more uniform brown, yellowish, or dusky, and dull in color. The dorsal and anal may have a very narrow white or pale margin. Very young specimens are uniformly very pale yellowish, without markings, fins colorless.

I have examined many living and fresh specimens, out of which the following were kept for further study: Seven from Culion, 295 to 405 mm long; 1 from Estancia, Panay, 120 mm long; 1 from Dumaguete, Oriental Negros Province, 275 mm long; 1 from Jolo, 345 mm long; 2 from Sibutu, 108 and 118 mm long; 12 from Sitankai, 43 to 330 mm long; 3 from Sandakan, British North Borneo, 204 to 258 mm long. The Stanford Museum also contains 3 from Cuyo, 175 to 215 mm long, and 1 from Bantayan Island, 280 mm long. The smallest Culion specimen is a spawning female, full of eggs.

I place here also 22 specimens taken on a reef in Singapore Harbor, their lengths varying from 42 to 331 mm. Most of them have a more or less definite ocellus on the opercle. Several of those from 265 to 320 mm long have but 28 to 30 teeth on each side of upper and lower jaw, while others agreeing in all other respects have 35, 38, 40, and up to 44 teeth. Some of these large specimens also have only about 230 scales in a longitudinal series. These large Singapore specimens have the depth

9 to a little more than 10 times, the head 6.7 to 7.45 times in length; the eye is 6 to 6.66 times in the head and 1.66 to 1.9 times in the snout, which is 3.5 to 3.6 times in the head.

This fish is of wide occurrence in the Philippines, from Luzon southward, and is especially abundant on reefs in the Sulu Sea and the South China Sea. It is found southward and eastward through the East Indies to northern and western Australia. It reaches a length of half a meter, or perhaps a little more. Although it is plentiful around rocks on shallow reefs, and is easily taken, it is very seldom eaten, and is not sought by fishermen.

This species not only undergoes considerable change with age, but is also subject to a large amount of variation among individuals of the same size. The number of teeth has been taken as a character of specific worth, but examination of numerous individuals shows that the teeth vary widely. The very young apparently have no more than 25 teeth on upper and lower jaw. With advancing age this number increases to 30 or more, but some large individuals seem never to have more than 30. The usual number in adults is 38 to 40, with no teeth at the front end of the jaws, the space there being vacant in most specimens. Where teeth develop clear to the tip of the jaw the number is 44. Very young specimens differ from the proportions given above. The measurements and proportions used here are for specimens over 200 mm long.

Bleeker described *Machærium nebulatum* from a single specimen, 370 mm long, taken at Singapore. I can find no characters sufficient to warrant its separation as a distinct species.

Genus CONGROGADOIDES Borodin

Congrogadoides BORODIN, Copeia No. 3 (October 15, 1933) 141.

This genus, probably of only subgeneric value, differs from *Congrogadus* in having a single small, hard, sharp spine before dorsal origin. There are two species, one from the Philippines, and one known only from a single small specimen from Australia.

CONGROGADOIDES HIERICHTHYS (Jordan and Richardson).

Congrogadus hierichthys JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (December 16, 1908) 285, fig. 11; HERRE, Fishes 1931 Philip. Exped. (1934) 100.

Dorsal I, 55 to 59; anal 46 to 49; 30 to 33 tubules in lateral line, 150 to 180 scales in a longitudinal series.

Depth 7.6 to 8.2, head 6.1 to 6.5 times in length; eye 6 to 6.33, snout 3.2 to 3.45 times in head, 1.77 to 1.97 times in snout. Usually from 27 to 30 teeth on each side of each jaw, but one

specimen has only 20 teeth. Around eyes, on top of head, and on upper margins of opercle and preopercle conspicuous pores with tumid blackish lips.

The form is like that of *Congrogadus subducens,* to which this species bears a strong resemblance.

In life dark red-brown or dark brown, with sometimes more or less green on head, under parts paler; sides sprinkled with more or less evident irregular pearly or whitish spots and short vertical bars. On opercle a conspicuous very dark-red or blackish ocellus with a narrow yellow margin. Dorsal, anal, and caudal brown, variegated with darker-brown spots arranged in bands.

Alcoholic specimens dark brown or red-brown, with a more or less evident black stripe across snout, eye, and preopercle to conspicuous blackish pale-margined ocellus on opercle; sides more or less irregularly spotted with white or pale flecks and short bars. Fins dusky, or dorsal and anal pale with 2 or 4 rows of dark spots on membranes.

The type, 106 mm long, collected at Cuyo, Palawan, is in the Stanford Museum. In addition I have collected and examined a specimen 64 mm long at Dumaguete, Oriental Negros Province; 5, 97 to 123 mm long, from Jolo; and 8 at Sitankai, 71 to 123 mm long.

This fish is called *tamayo* at Cuyo.

ILLUSTRATIONS

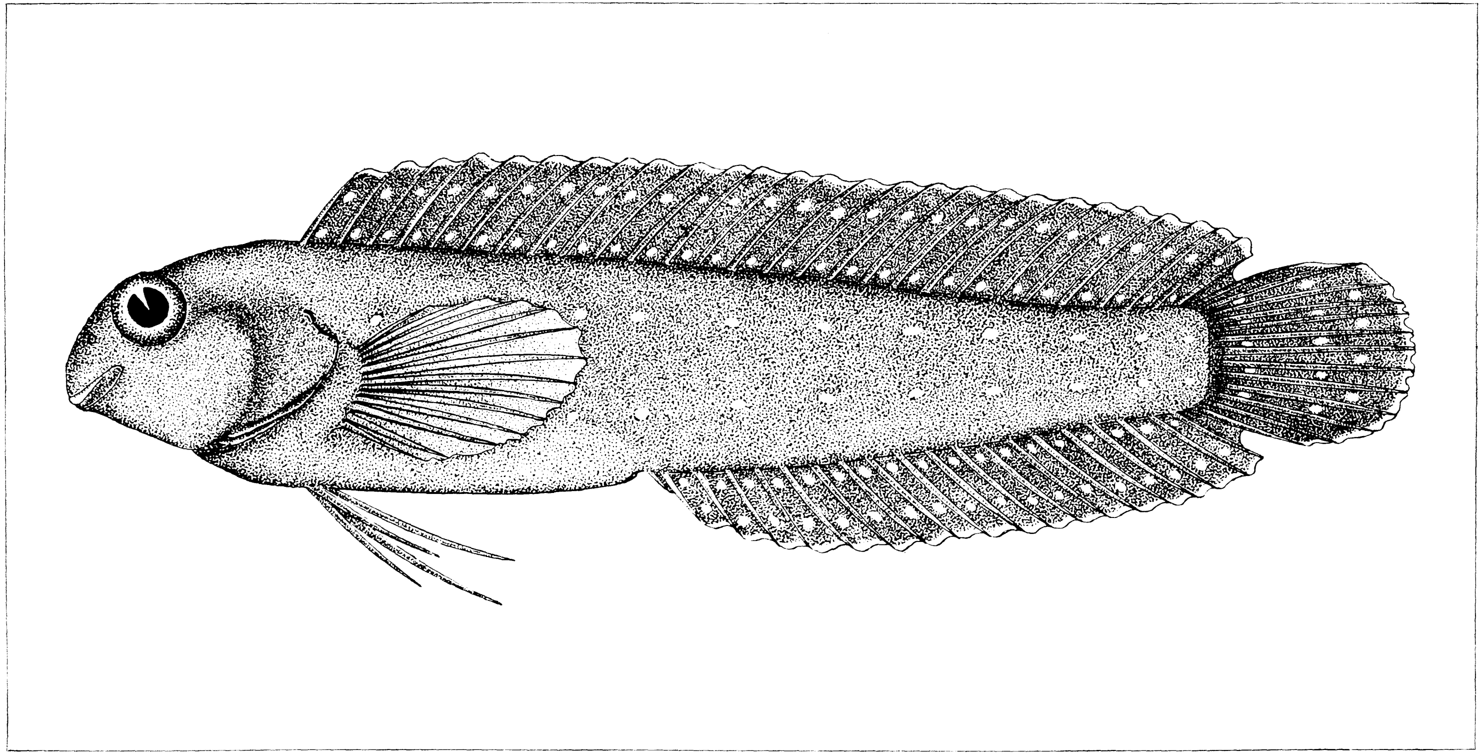


PLATE 1. ENCHELYURUS CÆRULO-PUNCTATUS SP. NOV.

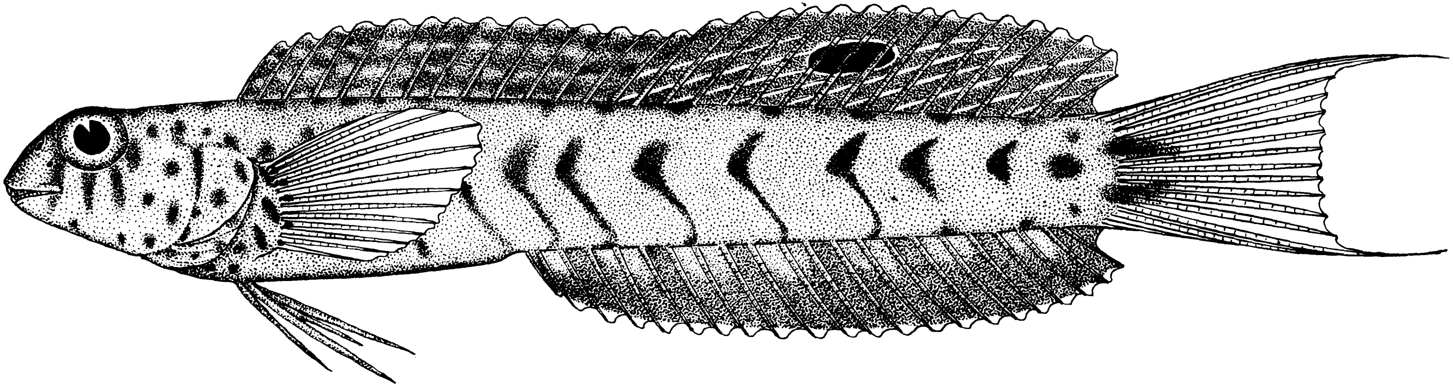


PLATE 2. PETROSCIRTES CALLOSOMA BLEEKER.

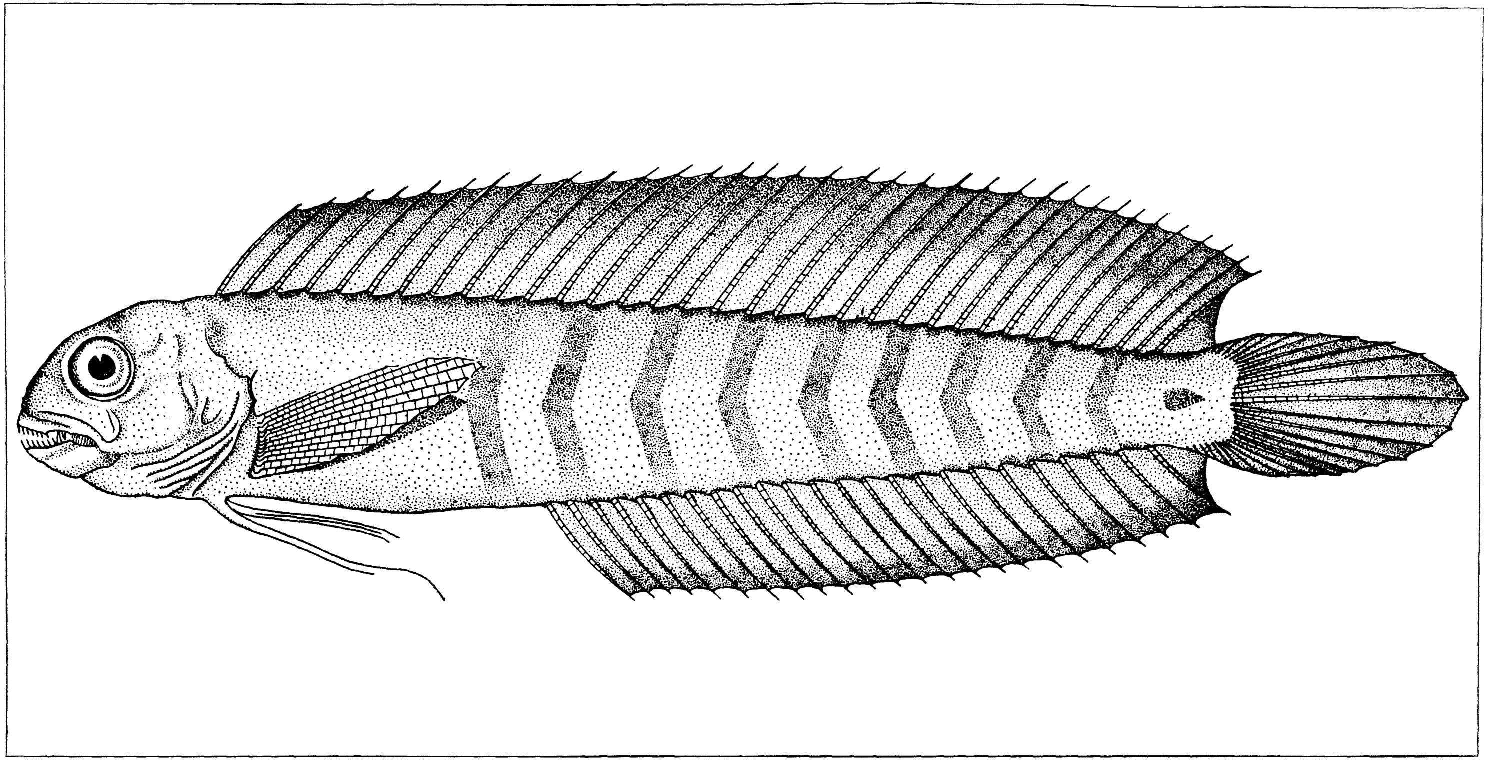


PLATE 3. PETROSCIRTES FEROX SP. NOV.

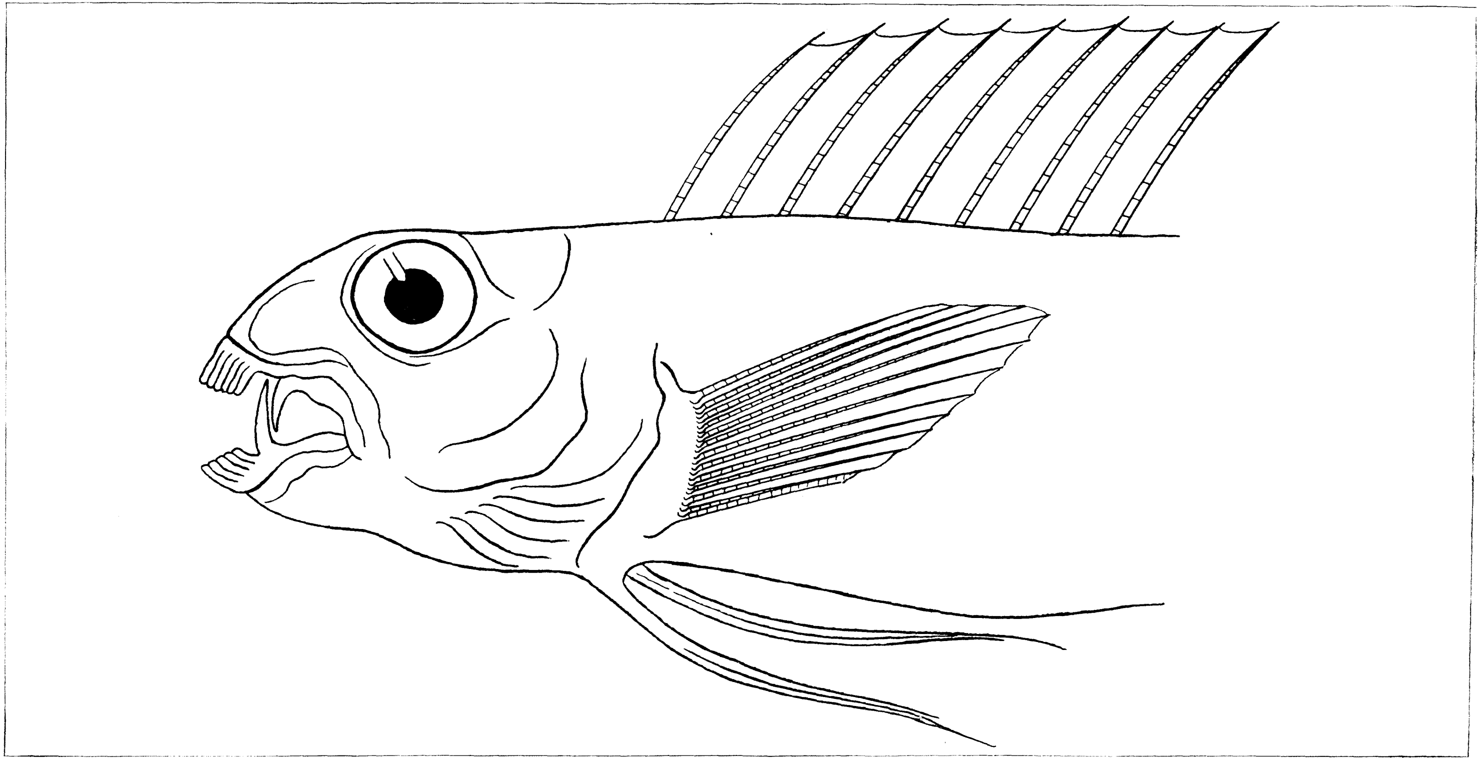


PLATE 4. PETROSCIRTES FEROX SP. NOV., ENLARGED, TO SHOW TEETH.

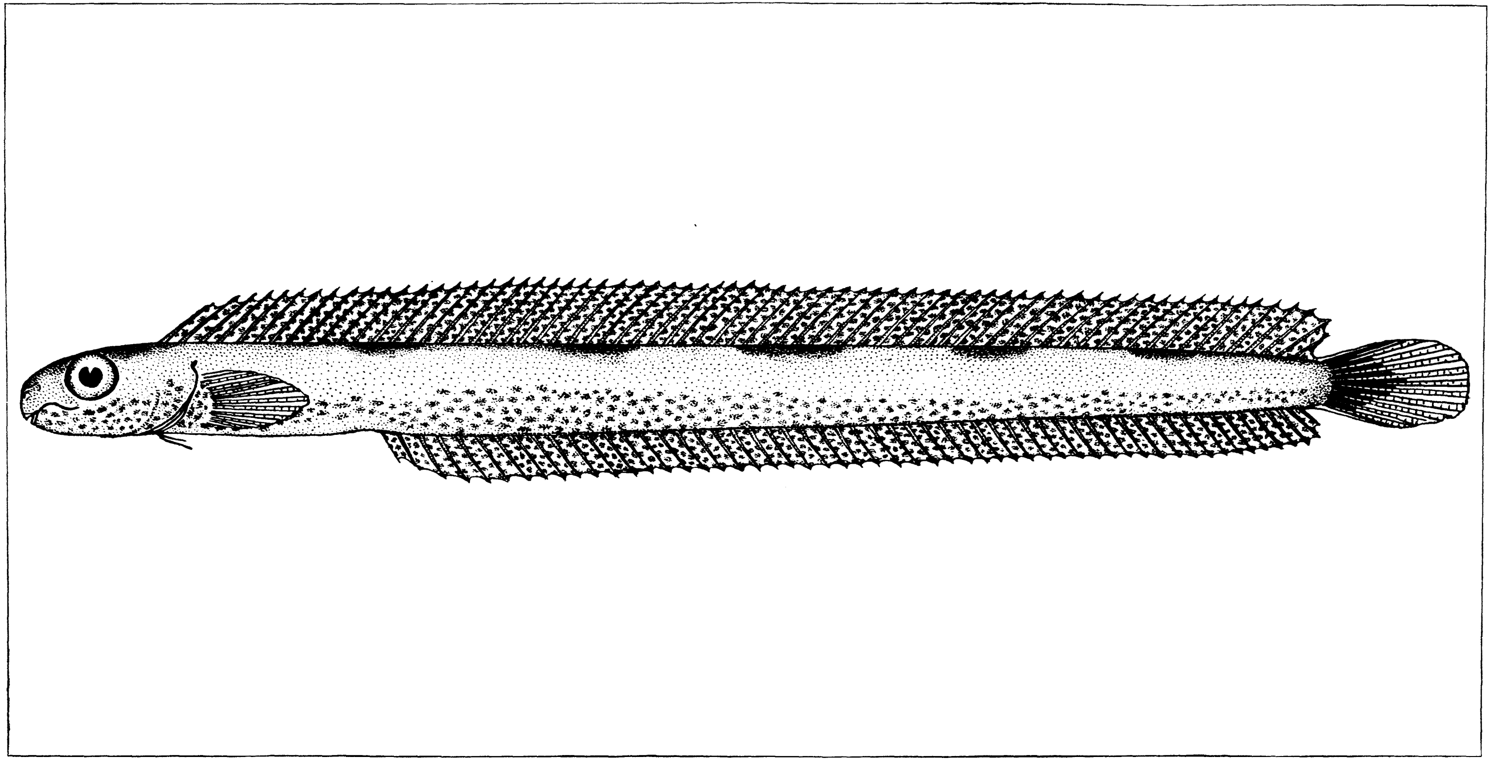


PLATE 5. LEMBEICHTHYS CELEBESENSIS SP. NOV.

VERTICAL DISTRIBUTION OF OYSTER SPAT IN BACOOR BAY, CAVITE PROVINCE

By DOMICIANO K. VILLALUZ

Of the Division of Fisheries, Department of Agriculture and Commerce Manila

TWO PLATES AND EIGHT TEXT FIGURES

This work is undertaken to determine the depths of the water where oyster larvæ are available in abundance for purposes of finding the best methods of collecting spats and to further the development and exploitation of other oyster grounds in the Philippines.

Studies of this nature were done by Nelson (2, 3, 4) and Perkins (8) on oyster larvæ in Barnegat Bay. These workers found that oyster larvæ rise with the flood tide and sink to the bottom during the ebb. They also found that the older stages of larvæ usually move upstream and away from the sea. Their explanation was that during flood tide water of high specific gravity remains along the bottom while water of lower density rises, and a transition zone called the "salicline" or "halicline" forms between these two regions. According to these authors, larvæ of oysters or other bivalves, as well as snails, are numerous in the region of the 'halicline." They explained further that during the ebb tide, especially in rough weather, the surface and bottom water mixes. As the larvæ keep close to the bottom and those of the setting size drop to the bottom, they are not carried seawards.

Prytherch (9) made an investigation on oyster larvæ in Milford Harbor, Connecticut. He found that setting was intense 1 foot above the low-water mark and 1 foot below it, gradually decreasing up to 2 feet above this mark, while directly on the bottom setting was very heavy. The reason given is that at low slack water, when setting takes place, the region of least current velocity is at the surface and does not extend to the bottom. Orton, (7) on the other hand, maintains that oyster larvæ are at the mercy of tidal currents and that their vertical migration is controlled in a measure by the power of the larvæ to swim or

to stop swimming at certain levels in the sea. He holds the opinion that oyster larvæ of all species behave similarly, and that they tend to fall to the bottom in still water in both flood tide and ebb.

The above workers agree that oyster larvæ at their setting stage reach the bottom in the process of their development and that they are present in varying quantities at different levels of the sea. Since the above conclusions are based on microscopical survey of the water samples taken at different regions of the sea for the presence of oyster larvæ in the plankton, the present writer decided to investigate the same problem in a different manner.

If the behavior of oyster larvæ is the same in all species of oysters; that is, if they tend to drop to the bottom once they reach the setting stage, more spats can be expected to set among the cultch placed at the bottom than elsewhere. The results of this investigation, however, do not bear out this expectation.

MATERIALS AND METHODS

Long collectors (Plate 1, fig. 1) as deep as the oyster beds (average low-water mark, 5 feet) were used. They were made up of pieces of No. 12 galvanized-iron wire 154 centimeters long and threaded with eleven old oyster shells of about uniform size, placed at intervals of 14 centimeters. Only clean oyster shells were used and carefully threaded onto the wire, with the smooth surface downward. The interval of 14 centimeters was maintained on the collectors with the use of a looping device (Plate 1, fig. 2) made of a piece of wood 1.5 by 4 inches by 7 feet with 11 ordinary nails 6 inches long placed at intervals of 14 centimeters. One end of the wire was looped around the eleventh nail before a shell collector was inserted. A second loop was made around the tenth nail and then a second shell collector was inserted. This process of looping the wire and inserting the shells was done alternately up to the first nail.

In this investigation a total of 44 long collectors were utilized. Two sets of 2 collectors each were placed in the Division of Fisheries oyster farm, at Binakayan, June 27 and July 5, 1938, respectively. September 1, 1938, 40 long collectors were distributed and set in the following regions in Bacoor Bay: 4 collectors among the oyster beds of Mabolo, Bacoor; 5 collectors among the oyster beds at the mouth of Bacoor River; 8 collectors among the oyster beds of Kawit; 4 collectors among the oyster

beds of Noveleta; 12 collectors in the Division of Fisheries oyster farm; 7 collectors among the oyster beds of Dalahican. All of these collectors were carefully set so that the last shell collectors touched the bottom.

Some collectors were examined for oyster spat after 21 days, and others after more than 3 months from the date of setting. A longer period of time was necessary before counting the spat, so that they could be seen easily with the naked eyes. Collectors hauled out of the water for examination were allowed to dry before the spat were counted.

RESULTS AND OBSERVATIONS

Collectors set in the Division of Fisheries oyster farm.—There were 16 collectors placed in the Division of Fisheries oyster farm bed. Two of these were set June 27 and another two July 5, 1938. These 4 collectors were removed from the water August 17, 1938, and the spat counted. The other 12 collectors were set September 1 and the spat counted November 16, 1938. Table 1 shows string collectors 1 to 4 and 21 to 32, with the corresponding number of spat caught on each shell collector. The first set of 2 string collectors is indicated in Table 2 as series 1, the second set of the same number of string collectors as series 2, and the third set of 12 string collectors as series 6. In all of these series, the sixth shell collector, placed 84 centimeters below the surface of the water, caught the most spat, 70, 81, and 147, respectively. The great difference between the average number of spat caught on shell collectors in series 1 and 2 and those of series 6 does not mean that the period between September 1 and November 16, 1938, when string collectors of series 6 was set, was a season of heavy setting of spat. Considering the number of string collectors included in series 1, 2, and 6, and taking the average number of spat caught on each shell collector at different fixed depths, series 6, which include 12 string collectors, will naturally exceed series 1 and 2, each composed of only 2 string collectors, in the average number of spat caught on each shell collector. On the other hand, the period between June 27 and August 17, 1938, when string collectors of series 1 and 2 were set, was a heavy setting season of spat, as indicated in Table 2. The average number of spat caught on the ninth shell collectors placed at 126 centimeters from the surface of the water, was 137 spat for all 44 string collectors. Out of this number 81 spat were caught on the

TABLE 1.—*Collectors and number of spats caught in different regions of Bacoor Bay.*

Date set.	Location of bed.	String collector No.	Tags No.	Shells.											Total number of spat.	Date counted.
				1	2	3	4	5	6	7	8	9	10	11		
1938																1938
June 27	Division of Fisheries oyster farm	1	43	9	15	25	28	31	49	30	25	23	0	0	235	Aug. 17
June 27	do	2	22	12	11	23	19	23	21	8	1	26	0	0	144	Aug. 17
July 5	do	3	16	8	9	43	22	13	49	33	17	4	0	0	198	Aug. 17
July 5	do	4	63	17	10	16	19	23	32	23	41	28	0	0	209	Aug. 17
Sept. 1	Mabolo, Bacoor	5	8	4	3	1	1	12	4	0	6	1	0	0	32	Sept. 21
Sept. 1	do	6	47	1	9	8	3	2	4	8	6	0	0	0	41	Sept. 21
Sept. 1	do	7	33	1	2	5	1	3	2	3	9	0	0	0	26	Sept. 21
Sept. 1	do	8	31	1	1	4	3	3	3	18	7	0	0	0	40	Sept. 21
Sept. 1	Kawit, Cavite	9	40	4	4	5	11	12	11	9	33	9	0	0	98	Oct. 13
Sept. 1	do	10	10	2	4	9	4	7	25	11	0	0	0	0	62	Oct. 13
Sept. 1	do	11	66	2	10	12	7	5	16	16	1	0	0	0	69	Oct. 13
Sept. 1	do	12	25	7	2	8	12	10	12	1	0	0	0	0	52	Oct. 13
Sept. 1	do	13	45	6	4	7	3	8	3	11	0	0	0	0	42	Oct. 13
Sept. 1	do	14	52	6	5	10	6	4	22	3	2	0	0	0	58	Oct. 13
Sept. 1	do	15	64	2	4	11	10	5	18	11	7	4	0	0	72	Oct. 13
Sept. 1	do	16	75	5	0	2	5	8	11	10	6	0	0	0	47	Oct. 18
Sept. 1	Noveleta, Cavite	17	34	8	2	6	2	9	13	23	15	12	0	0	90	Oct. 18
Sept. 1	do	18	3	7	8	1	5	2	8	12	21	0	0	0	64	Oct. 18
Sept. 1	do	19	29	1	3	12	4	9	10	12	24	0	0	0	75	Oct. 18
Sept. 1	do	20	41	8	0	3	11	0	10	11	9	10	0	0	62	Oct. 18
Sept. 1	Division of Fisheries oyster farm	21	14	3	2	0	3	0	8	11	6	0	0	0	33	Nov. 16
Sept. 1	do	22	57	9	2	10	14	9	1	12	12	0	0	0	69	Nov. 16
Sept. 1	do	23	9	22	4	2	4	10	12	9	0	0	0	0	63	Nov. 16
Sept. 1	do	24	68	3	7	18	3	4	9	10	0	0	0	0	54	Nov. 16
Sept. 1	do	25	30	12	0	7	17	13	24	12	4	0	0	0	89	Nov. 16
Sept. 1	do	26	19	14	6	4	8	11	26	7	1	0	0	0	77	Nov. 16
Sept. 1	do	27	54	14	5	7	11	7	11	9	3	0	0	0	67	Nov. 16
Sept. 1	do	28	73	9	7	4	1	1	2	4	0	0	0	0	28	Nov. 16

Sept. 1	----do-------------------------	29	1	4	3	12	20	18	10	11	4	0	0	0	81	Nov. 16
Sept. 1	----do-------------------------	30	26	4	3	7	10	4	9	9	13	2	0	0	61	Nov. 16
Sept. 1	----do-------------------------	31	4	3	6	10	14	6	15	8	5	0	0	0	67	Nov. 16
Sept. 1	----do-------------------------	32	20	3	9	1	9	9	20	11	6	0	0	0	68	Nov. 16
Nov. 17	Mouth of Bacoor River ----------	33	24	0	0	0	0	0	0	0	0	0	0	0	0	Dec. 12
Nov. 17	----do-------------------------	34	5	0	0	0	0	0	0	0	1	0	0	0	1	Dec. 12
Nov. 17	----do-------------------------	35	72	0	0	0	0	0	0	0	0	0	0	0	0	Dec. 12
Nov. 17	----do-------------------------	36	50	0	0	0	0	0	0	0	0	0	0	0	0	Dec. 12
Nov. 17	----do-------------------------	37	67	0	0	0	1	0	0	0	0	0	0	0	1	Dec. 12
Sept. 1	Dalahican----------------------	38	7	2	3	6	8	8	1	8	11	0	0	0	47	Dec. 12
Sept. 1	----do-------------------------	39	38	5	9	12	1	11	11	5	4	0	0	0	58	Dec. 12
Sept. 1	----do-------------------------	40	81	8	8	9	6	5	0	1	6	11	0	0	54	Dec. 12
Sept. 1	----do-------------------------	41	15	8	8	8	9	5	5	22	29	0	0	0	94	Dec. 12
Sept. 1	----do-------------------------	42	21	2	3	3	11	16	7	4	9	7	0	0	62	Dec. 12
Sept. 1	----do-------------------------	43	2	15	7	6	5	9	5	0	0	0	0	0	47	Dec. 12
Sept. 1	----do-------------------------	44	9	6	12	7	10	1	8	10	4	0	0	0	58	Dec. 12

ninth shell collectors of series 1 and 2, and only 2 spat were caught on the ninth shell collectors of series 6. Text figs. 1, 2, and 3 show that the tenth and eleventh shell collectors placed at depths of 140 and 154 centimeters, respectively, are without

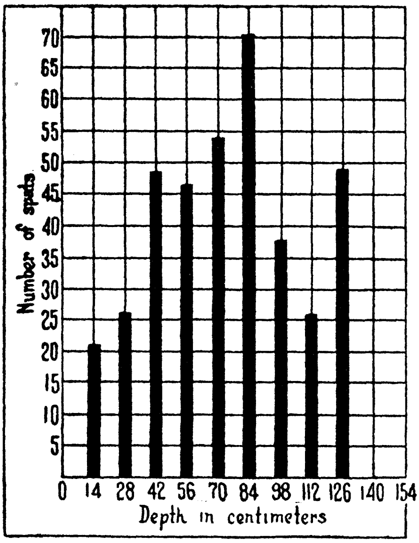


FIG. 1. Average number of spat caught on shell collectors set from June 27 to August 17, 1938, in the Division of Fisheries oyster farm.

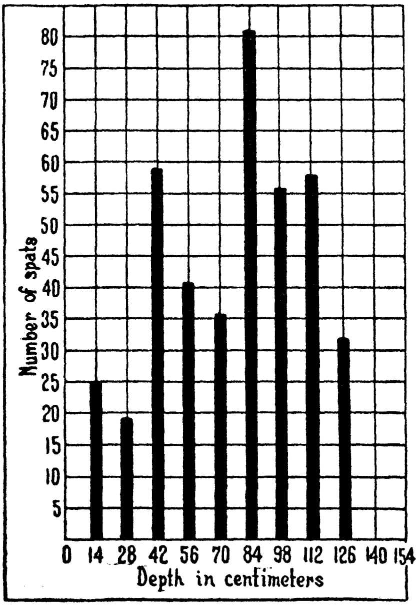


FIG. 2. Average number of spat caught on shell collectors set from July 5 to August 17, 1938, in the Division of Fisheries oyster farm.

TABLE 2.—*Number of spat caught on shell collectors at fixed distances from the surface of water.*

Shell collector.	Depth.	No. of spat.							Average.
		Series 1.	Series 2.	Series 3.	Series 4.	Series 5.	Series 6.	Series 7.	
	cm.								
1	14	21	25	7	34	24	100	46	257
2	28	26	19	15	33	13	54	50	210
3	42	48	59	18	64	22	82	51	344
4	56	47	41	8	58	22	114	50	340
5	70	54	36	20	59	20	92	55	336
6	84	70	81	13	118	41	147	37	507
7	98	38	56	29	72	58	113	50	416
8	112	26	58	28	49	69	54	63	347
9	126	49	32	1	13	22	2	18	137
10	140	0	0	0	0	0	0	0	0
11	154	0	0	0	0	0	0	0	0
Total	--------	379	407	139	500	291	758	420	

spat. This is also true in the case of the other string collectors set in the different regions of Bacoor Bay. This result may be due to the muddy condition of the bottom of oyster beds in the entire Bay, where the mud is about 2 feet deep and not compact. A slight movement of water, caused by waves and current, stirs the surface of the muddy bottom so that the layer of water along the surface becomes silty, and silt seems to have a deleterious effect on the life of oyster spat. Even mature oysters raised by the hanging method of oyster culture die whenever they drop to the muddy bottom. When some of those still alive were examined, much silt was found adhering along the sides of the mantle cavity and among the gill filaments.

Collectors set among the oyster beds in Mabolo, Bacoor.—Four string collectors were set in this place September 1 and examined for oyster spat September 21, 1938. Table 1 shows string collectors 5, 6, 7, and 8 together with the number of spat caught on the individual shell collectors. This set of string collectors is indicated as series 3, and Table 2 gives the average number of spat caught on shell collectors at fixed distances from the surface of the water. Only 139 spat were caught on these collectors, due probably to the shorter period of time these collectors had stayed under water as compared with that of the other collectors. Moreover, the oyster beds found along the shore of the town of Bacoor are not as

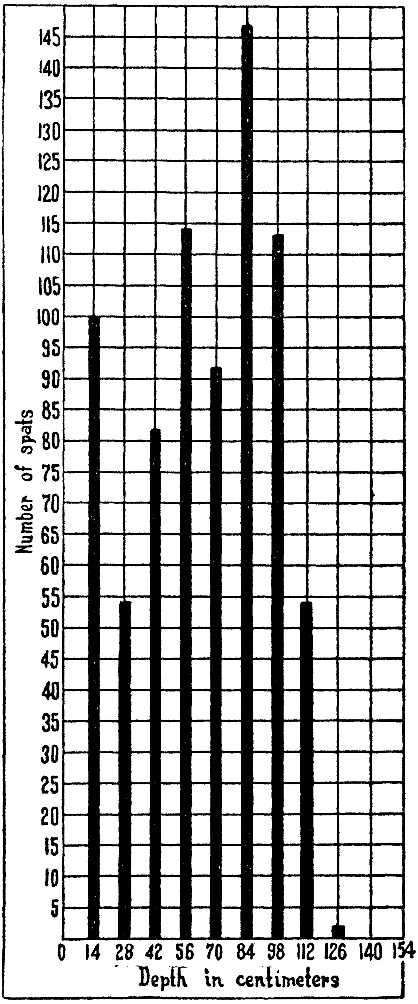


FIG. 8. Average number of spat caught on shell collectors set from September 1 to November 16, 1938, in the Division of Fisheries oyster farm.

productive and conducive to the development and growth of spat as those found along the shores of Binakayan, Kawit, Noveleta, and Dalahican. The bottom of oyster beds along the shore of the town of Bacoor is constantly disturbed as a result of the daily gathering of shells which are used in the manufacture of lime.

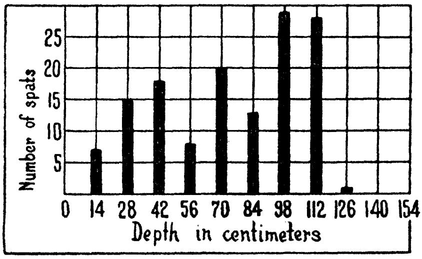


FIG. 4. Average number of spat caught on shell collectors set from September 1 to 21, 1938, in Mabolo, Bacoor, Cavite Province.

Collectors set among the oyster beds in Noveleta.—Four string collectors were set in Noveleta September 1 and the spat counted October 18, 1938. Table 1 shows string collectors 17 to 20 together with the number of spat caught on each shell collector. In Table 2 this set of collectors is indicated as series 5. It will be noticed that numerous spat were found on the eighth shell collectors placed at a depth of 112 centimeters from the surface of the water. Text fig. 5 shows the average number of spat caught on shell collectors set in this region of Bacoor Bay. At depths of from 42 to 70 centimeters from the surface there was a very slight decrease in the number of spat caught, while a sudden increase was attained at from 84 to 112 centimeters from the surface of the water.

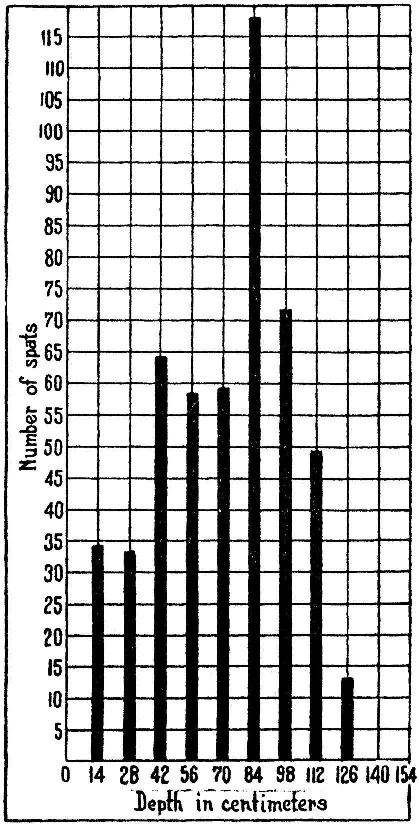


FIG. 5. Average number of spat caught on shell collectors set from September 1 to October 13, 1938, in Kawit, Cavite Province.

Collectors set among the oyster beds in Dalahican.—Seven string collectors were set in Dalahican September 1, and the spat counted December 12, 1938. Table 1 shows collectors 38 to 44, together with the spat caught on each shell collector. These collectors are indicated in Table 2 as series 7. Fig. 7 indicates that spat

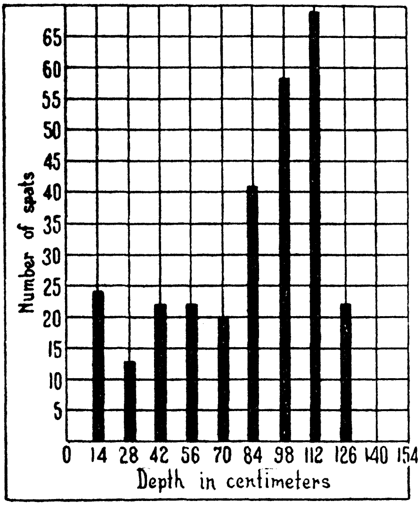


FIG. 6. Average number of spat caught on shell collectors set from September 1 to October 18, 1938, in Noveleta, Cavite Province.

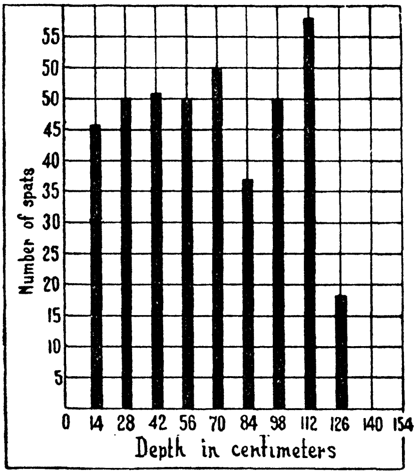


FIG. 7. Average number of spat caught on shell collectors set from September 1 to December 12, 1938, in Dalahican, Cavite Province.

were almost evenly distributed at depths of from 14 to 112 centimeters from the surface, except at the region of the sixth shell collector at a depth of 84 centimeters where the average number of spat was only 37. Spat were absent at depths of from 140 to 154 centimeters from the surface of the water.

Collectors set at the mouth of Bacoor River.—Five string collectors were set at the mouth of Bacoor River November 17 and the spat counted December 12, 1938. Table 1 shows collectors 33 to 37. Only string collectors 34 and 37 were able to catch

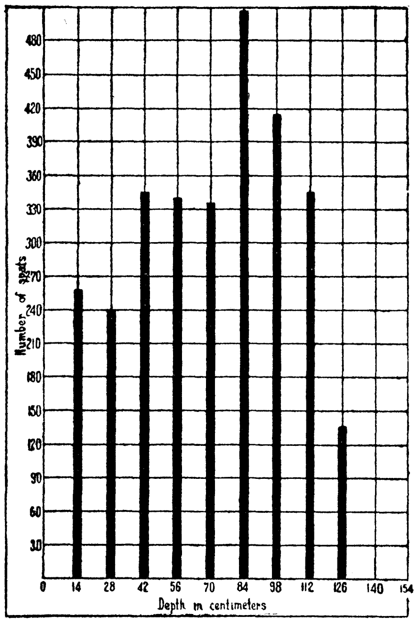


FIG. 8. Vertical distribution of spat in Bacoor Bay.

one spat each on shell collectors 8 and 4, respectively, due probably to the occurrence of heavy rainfall during the period covered by the experiment, which may have caused the water at the mouth of the river to become fresh and unsuitable for the life of oyster spat. Also, the mouth of Bacoor River has a heavy deposit of sand and mud which caused the water to become silty. Nelson(6) has shown that oyster larvæ, while in muddy water, fill the digestive tract with dirt instead of with their ordinary food. He also observed that oyster larvæ in the laboratory fed with fine suspension of mud die within a day or two, while larvæ placed in clear sea water are able to live for 10 days.

DISCUSSION OF RESULTS

The average number of spat caught on string collectors in Bacoor Bay is given in Table 3. The 16 string collectors set in the Division of Fisheries oyster farm at Binakayan caught the greatest number of spat, 96 being the average number caught on each string collector. The 4 string collectors set among the oyster beds in Noveleta ranked second, with 72 as the average number of spat caught on each shell collector. The collectors set among the oyster beds in Kawit, Dalahican, and Mabolo, ranked third, fourth, and fifth, respectively, with 62, 60, and 34 spat, respectively, to each string collector. The 5 string collectors set at the mouth of Bacoor River caught only 2 spat.

TABLE 3.—*Average number of spat caught on string collectors in Bacoor Bay.*

Location of bed.	Number of string collectors.	Number of spat caught.	Average number of spat per collector.
1. Binakayan	16	1,544	96
2. Noveleta	4	291	72
3. Kawit	8	500	62
4. Dalahican	7	420	60
5. Mabolo	4	139	34
6. Bacoor River (mouth)	5	2	----------

Text fig. 8 presents the vertical distribution of oyster spat in Bacoor Bay, at fixed depths from the surface of the water to the bottom. It will be seen that spat are available in abundance at depths of from 42 to 112 centimeters from the surface of the water. The greatest intensity of setting is obtained at 84 centimeters from the surface of the water. The figure also

shows the presence of a considerable number of spat at a depth of 28 centimeters from the surface of the water, whereas in about the same place they are totally absent at the same distance from the bottom.

SUMMARY AND CONCLUSIONS

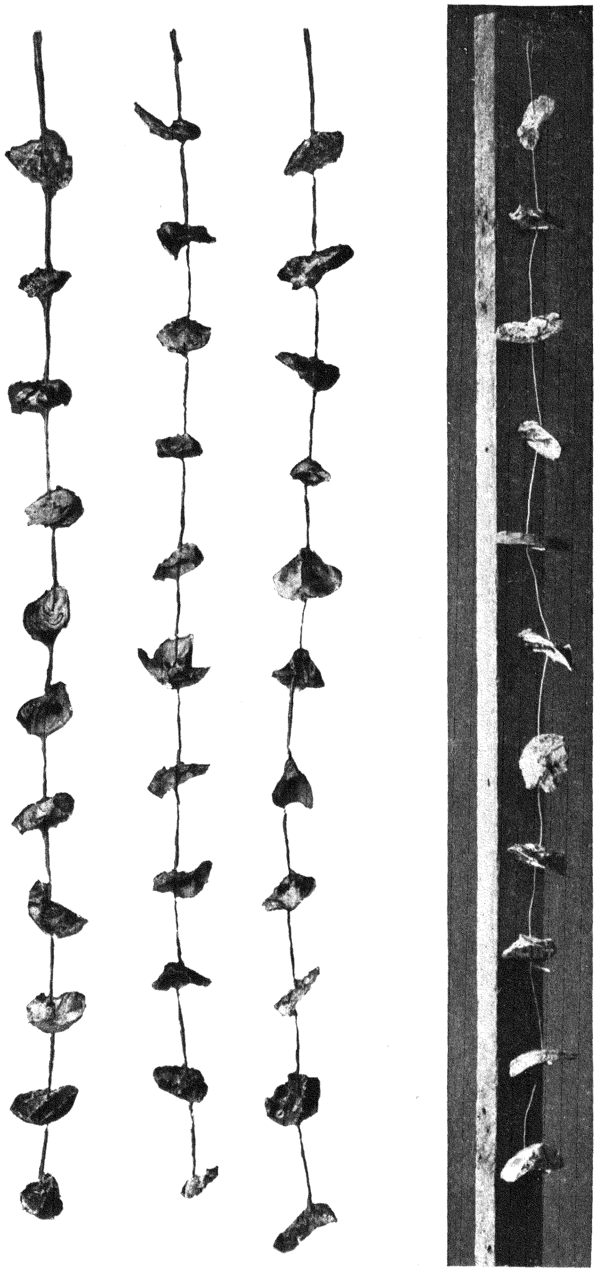
1. Oyster spat are available at depths ranging from 14 to 126 centimeters from the surface of the water. They are abundantly present at a depth of 84 centimeters from the surface, while at depths ranging from 140 to 154 centimeters they are totally absent in the oyster beds in Bacoor Bay.

2. To catch the maximum number of spats in Bacoor Bay it is necessary that all string collectors be not less than 112 centimeters long from the surface of the water.

REFERENCES

1. HOPKINS, A. E. Experimental observations on spawning, larval development, and setting in the Olympia oyster Ostrea lurida. Bull. 23 U. S. Bur. Fish. **48** (1937) 439–503.
2. NELSON, TH. C. Report of the department of Biology, New Jersey Agricultural Experiment Station (1925) 283, 284.
3. NELSON, TH. C. Ibid. (1926) 107–109.
4. NELSON, TH. C. Ibid. (1927) 79–82.
5. NELSON, TH. C. Ibid. (1930) 5–24.
6. NELSON, TH. C. Aids to successful oyster culture. New Jersey Agricultural Experiment Station (1921) 5–59.
7. ORTON, J. H. Oyster Biology and Oyster Culture. Edward Arnold & Co. London (1937).
8. PERKINS, E. B. A study of the oyster problems in Barnegat Bay. Annual Rept. Dept. of Biol. N. Jersey Agricultural Experiment Station (1930) 25–47.
9. PRYTHERCH, H. F. Investigation of the physical conditions controlling spawning of oysters and the occurrence, distribution, and setting of oyster larvæ in Milford Harbor, Connecticut. Bull. U. S. Bur. Fish. **44** (1928) 429–503.

ILLUSTRATIONS



1 2

PLATE 1.

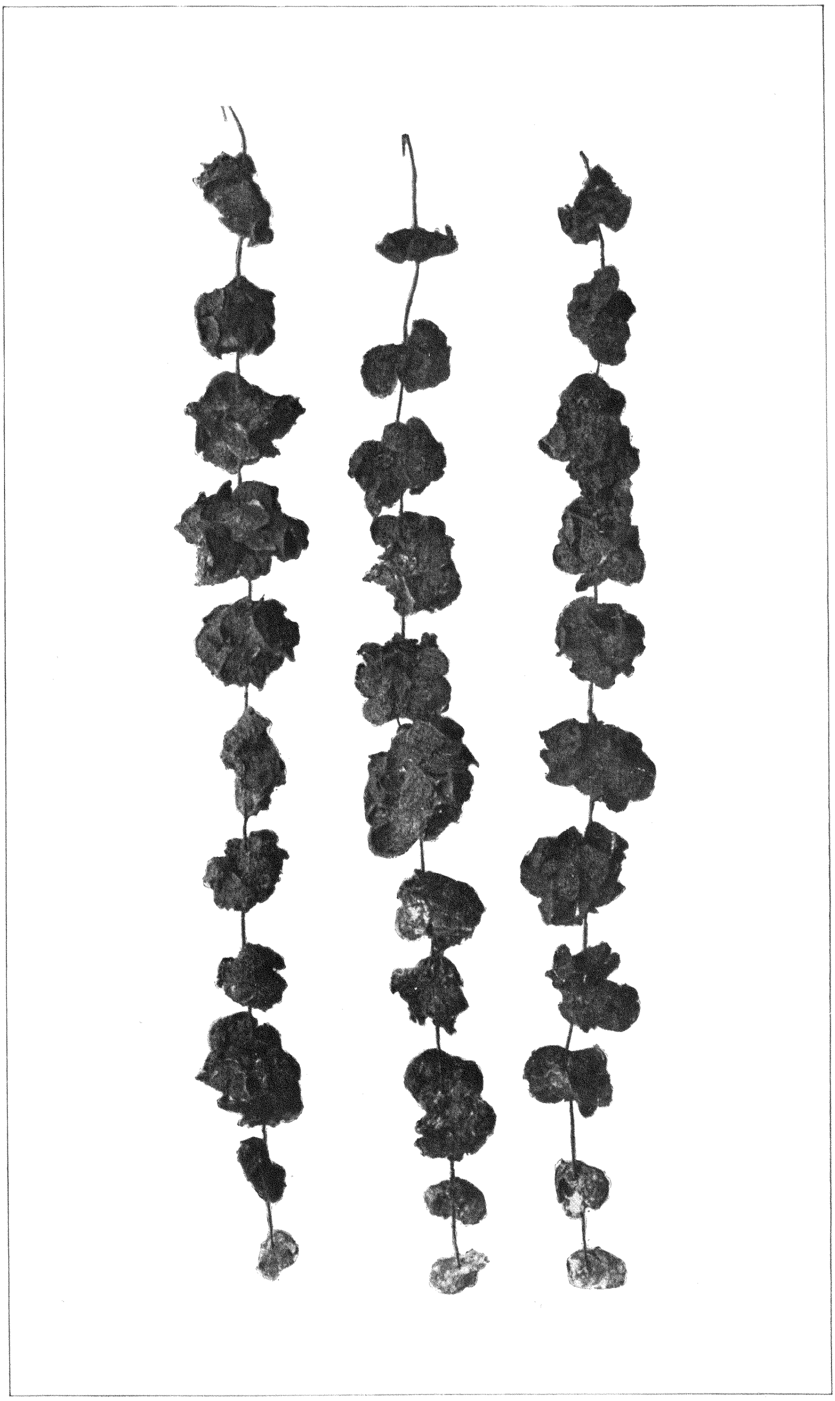


PLATE 2.

FOUR NEW PHILIPPINE SPECIES OF FRESH-WATER SHRIMPS OF THE GENUS CARIDINA

By GUILLERMO J. BLANCO

Of the Division of Fisheries, Department of Agriculture and Commerce Manila

THREE PLATES

The description of these apparently new species of shrimps is based upon material collected from Laoag River, Laoag, Ilocos Norte Province, December 31, 1938, by Mr. Eulogio J. Martinez, and from a mountain stream, Helosig, Leyte, 1,500 feet above sea level, May 23, 1937, by Messrs. Dioscoro S. Rabor and M. Celestino, both of the Division of Fisheries, Bureau of Science.

Genus CARIDINA Milne-Edwards

Caridina MILNE-EDWARDS, Histoire Naturelle des Crustaces 2 (1837).

CARIDINA VILLADOLIDI sp. nov. Plate 1, figs. 1 to 9.

Rostrum straight, saberlike, nearly reaching level of antennal scale; upper edge without teeth; lower edge with 6 teeth on distal half of its total length; a pair of setæ posterior of rostrum (Plate 1, fig. 1). Antennal spine sharp; anteroinferior angle of carapace sharp-pointed. Eyes normal. Antennular peduncle reaching beyond tip of spine of antennular peduncle scale; basal segment not reaching beyond half of length of rostrum; second segment long, twice its width. Antennal scale slender, three times as long as broad. Mandible with three spines of incisor process and setæ (Plate 1, fig. 2). Terminal joint of third maxilliped (Plate 1, fig. 3) with eight spines and numerous setæ. Carpus of first peræopod (Plate 1, fig. 4) twice as long as distal breadth, excavation at distal end slightly crescent-shaped. Hairs of mobile and immobile fingers of chela not very long. Palm of chela of second peræopod not similar to that of first; distal end of carpus not excavated (Plate 1, fig. 5). Dactylus of third pair (Plate 1, fig. 6) with seven spines; that of fifth pair (Plate 1, fig. 7) with 44 spinules. Body robust, dorsally rounded, depth of second abdominal somite twice in body. Pleopods short and foliaceous. Apex of telson (Plate 1,

fig. 8) triangular, with a sharp midpoint, two curved-in externolateral spines, and seven internolateral unequal spines with setæ. Uropodial spinules 17 in each.

Eggs 0.50 mm long, 0.36 wide.

Type locality.—Laoag River, Laoag, Ilocos Norte Province, Luzon.

Live specimens grayish with small specks. Preserved specimens yellowish. One type specimen, Cat. No. 40, 26 mm from tip of rostrum to tip of telson.

I take pleasure in naming this species after Dr. Deogracias V. Villadolid, zoölogist of the Division of Fisheries, Department of Agriculture and Commerce.

Caridina villadolidi is closely related to *C. angulata* Bouvier with respect to the number of spines of the dactylus of the third and fifth pair of peræopods and diameter of eggs. It differs, however, from the latter by having 17 uropodial spinules, instead of 19 or 20, as in *C. angulata.* The apex of the telson and the basal angle of the uropodial spines of this new species also differ greatly from those of *C. angulata.*

CARIDINA LAOAGENSIS sp. nov. Plate 2, figs. 1 to 8.

Rostrum short, slightly curved downwards, not reaching third segment of antennule; upper border with 12 to 18 teeth; lower border with 4 or 5 teeth (Plate 2, fig. 1). Antennal spines below eye orbit sharp-pointed; anteroinferior angle of carapace not rounded. Eyes normal, two times as long as broad, ocellus distinct (Plate 2, fig. 2). Antennular peduncle not reaching beyond tip of spine of antennal scale; basal segment reaching beyond first posterior tooth of lower border of rostrum. Antennal scale three times as long as broad. Terminal joints of third maxilliped not reaching beyond antennular peduncle. Mandible (Plate 2, fig. 3) with five spines of incisor process and setæ. Carpus of first pair of peræopods as long as distal breadth; excavation at distal end crescent-shaped. Mobile and immobile fingers of chela with short hairs (Plate 2, fig. 4). Carpus of second pair of peræopods 4.75 times as long as broad (Plate 2, fig. 5). Dactylus of third pair with seven spines and setæ (Plate 2, fig. 6). Body robust, depth of second abdominal somite twice in length of body. Pleopods short, foliaceous. Telson 1.33 times as long as sixth somite, with three pairs of dorsal spines; apex of telson with two pairs of setæ, with two small externolateral spines, two pairs of similar spines, and in between two pairs

of unequal long setæ. Uropodial spinules 20 in each outer uropod.

Eggs 0.43 mm long and 0.29 wide.

Live specimens blackish with a yellow narrow band on dorsal side of body. Preserved specimens dark orange.

Type, Cat. No. 41, and several cotypes, 20 to 25 mm long from tip of rostrum to tip of telson.

Caridina laoagensis is allied to *C. annandalei* Kemp and *C. lævis* Heller with respect to the rostrum which does not reach the end of the antennular peduncle or beyond the antennal scale. It resembles *C. lævis* with respect to the excavation at the distal end of the carpus of the first pair of peræopods, but differs from *C. annandalei* by having no excavation on the distal end of the carpus. *C. laoagensis* is very distinct, because it has a greater number of spinules on its outer uropods, and the apex of its telson is not similar to that in other species of the genus. The eggs are smaller than those of *C. annandelei.*

CARIDINA LEYTENSIS sp. nov. Plate 3, figs. 1 to 7.

Rostrum straight, short, not reaching beyond end of second segment of antennular peduncle. Upper border with eight to ten teeth; lower border with one or no teeth. Antennal spine sharp-pointed; anteroinferior angle of carapace not rounded (Plate 3, fig. 1). Breadth of cornea 1.75 dorsal length of eye; ocellus distinct. Antennular peduncle not reaching beyond tip of spine of antennal scale. End of basal segment of antennular peduncle reaching beyond last posterior of the upper edge of rostrum. Second segment of antennular peduncle 2.33 times as long as broad. Terminal joint of third maxilliped (Plate 3, fig. 2) with four spines and setæ. Carpus of first peræopod (Plate 3, fig. 3) twice as long as distal breadth; no excavation on distal end. Hairs of mobile and immobile fingers short. Carpus of second peræopod (Plate 3, fig. 4) about five times as long as wide; distal end of carpus not excavated. Dactylus of third with four spines and setæ (Plate 3, fig. 5). Body slightly compressed, sixth somite twice as long as wide. Pleopods long, foliaceous. Apex of telson triangular, with two small externolateral spines and four pairs of internolateral spines, six of which are equal in length, the two extremes longer than the inner four. Uropodial spinules 14.

Type locality.—Helosig, Leyte.

Type, Cat. No. 42, and cotype, both 7 mm long from tip of rostrum to tip of telson.

Caridina leytensis is closely related to *C. kilimæ* Hilgendorf in the shape of the rostrum, but differs by having a greater number of spinules of the outer uropods, and in the shape of the apex of its telson.

CARIDINA CELESTINOI sp. nov. Plate 3, figs. 8 to 10.

Rostrum short, not reaching beyond end of basal segment of antennular peduncle; upper edge with one tooth; lower edge without teeth but with a pair of setæ. Antennal spine acutely pointed, anteroinferior angle also acutely pointed. Eyes 1.75 times as long as broad, ocellus well-marked. Antennular peduncle (Plate 3, fig. 8), reaching tip of lamella of antennal scale. Dorsal and ventral ends of basal segment and second segment with spinules and setæ. Second segment of antennular peduncle 1.75 times as long as wide dorsally. Terminal joint of third maxillipeds reaching beyond tips of antennal scale and antennular peduncle. Carpus of first peræopod (Plate 3, fig. 9) 2.75 times as long as distal breadth; no excavation of distal end. Telson with two pairs of dorsal spines as long as sixth somite dorsally. Mountain stream, Helosig, Leyte.

Preserved specimen dark yellowish.

Type, Cat. No. 43, 4 mm long.

Caridina celestinoi is very distinct from other known species in the character of its rostrum, which has one tooth at the middle of the upper edge and a pair of long setæ on the lower edge.

I take pleasure in naming this dwarf shrimp after Mr. Manuel Celestino, one of the collectors of the specimens.

LITERATURE CITED

BLANCO, G. J. The Atyidæ of the Philippines. Philip. Journ. Sci. 56 (1935) 29–39, pls. 1–3.

BLANCO, G. J. A new species of Palæmon from northern Luzon. Philip. Journ. Sci. 67 (1938) 201–205, pl. 1, figs. 1–11.

BORRADAILE, L. A. On some crustaceans from the south Pacific. Proc. Zoöl. Soc. London 3 (1898) 1000–1005, pls. 63–65.

BOUVIER, E. L. Recherches sur la morphologie, les variations, la distribution geographique des crevettes de la famille des atyides. Encyclopédie Entomologique (1925).

CALMAN, W. T. On two species of macrurous crustaceans from Lake Tanganyika. Proc. Zoöl. Soc. London (1899) 704–712, pls. 39, 40.

CALMAN, W. T. Zoölogical results of the Third Tanganyika Expedition. Report on the macrurous crustacea. Proc. Zoöl. Soc. London (1906) 187–206, pls. 11–14.

CALMAN, W. T. The researches of Bouvier and Bordage on mutations in crustacea of the family Atyidæ. Quart. Journ. Mic. Soc. 55 (1910) 785–797.

ESTAMPADOR, E. P. A check list of Philippine crustacean decapods. Philip. Journ. Sci. 62 (1937) 485, 486.

DANA, J. P. Crustacea U. S. Explor. Exp. (1) 13 (1852) 531–541, pl. 34.

HICKSON, S. J. On a new species of the genus Atya (A. wyckii) from Celebes. Ann. & Mag. Nat. Hist. (2) 6 (1888) 357–367, pls. 12–14.

KEMP, ST. Fauna of the Inle Lake Crustacea Decapoda of the Inle Lake Basin. Rec. Ind. Museum 14 (1918) 81–102, pls. 24, 25.

LANCHESTER, W. F. On some malacostracous crustaceans from Malaysia in the collection of the Sarawak Museum. Ann. & Mag. Nat. Hist. (7) 6 (1900) 249–265, pl. 12.

ILLUSTRATIONS

[All drawings were made by Guillermo J. Blanco, with the aid of a camera lucida.]

PLATE 1. CARIDINA VILLADOLIDI SP. NOV.

FIG. *1*. Lateral view of rostrum, × 30; *2*, mandible, × 50; *3*, terminal segment of third maxilliped, × 30; *4*, chela and carpus of first peræopod, × 30; *5*, chela and portion of carpus of second peræopod; *6*, dactylus of third pair, × 50; *7*, dactylus of fifth pair, × 30; *8*, portion of telson, × 50; *9*, uropodial spinules, × 50.

PLATE 2. CARIDINA LAOAGENSIS SP. NOV.

FIG. *1*. Lateral view of rostrum, × 30; *2*, eye, × 30; *3*, mandible, × 50; *4*, chela, carpus, and propodus of first pair of peræopods, × 30; *5*, chela and carpus of second pair of peræopods, × 30; *6*, dactylus of third pair of peræopods, × 50; *7*, portion of telson; *8*, uropodial spinules, × 50.

PLATE 3

FIG. *1*. *Caridina leytensis* sp. nov., lateral view, anterior cephalothorax, × 50; *2*, *Caridina leytensis* sp. nov., terminal joint of third maxilliped, × 30; *3*, *Caridina leytensis* sp. nov., peræopod of first pair, × 60; *4*, *Caridina leytensis* sp. nov., peræopod of second pair, × 60; *5*, *Caridina leytensis* sp. nov. dactylus of third pair, × 60; *6*, *Caridina leytensis* sp. nov., apex of telson, 60; *7*, *Caridina leytensis* sp. nov., uropodial spinules, × 60; *8*, *Caridina celestinoi* sp. nov., lateral view, anterior cephalothorax, × 50; *9*, *Caridina celestinoi* sp. nov., peræopod of first pair, × 50; *10*, *Caridina celestinoi* sp. nov., lateral view of telson and uropods, × 50.

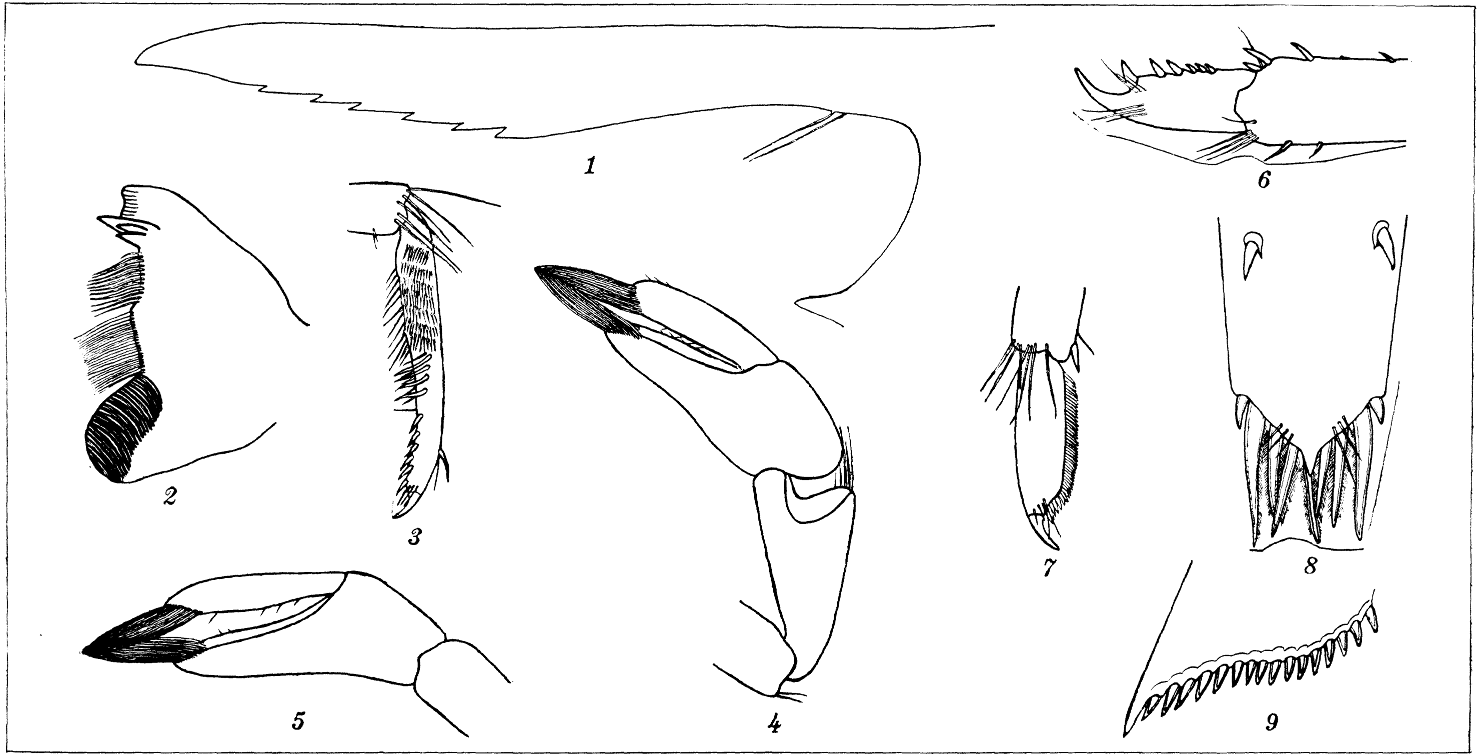


PLATE 1. CARIDINA VILLADOLIDI SP. NOV.

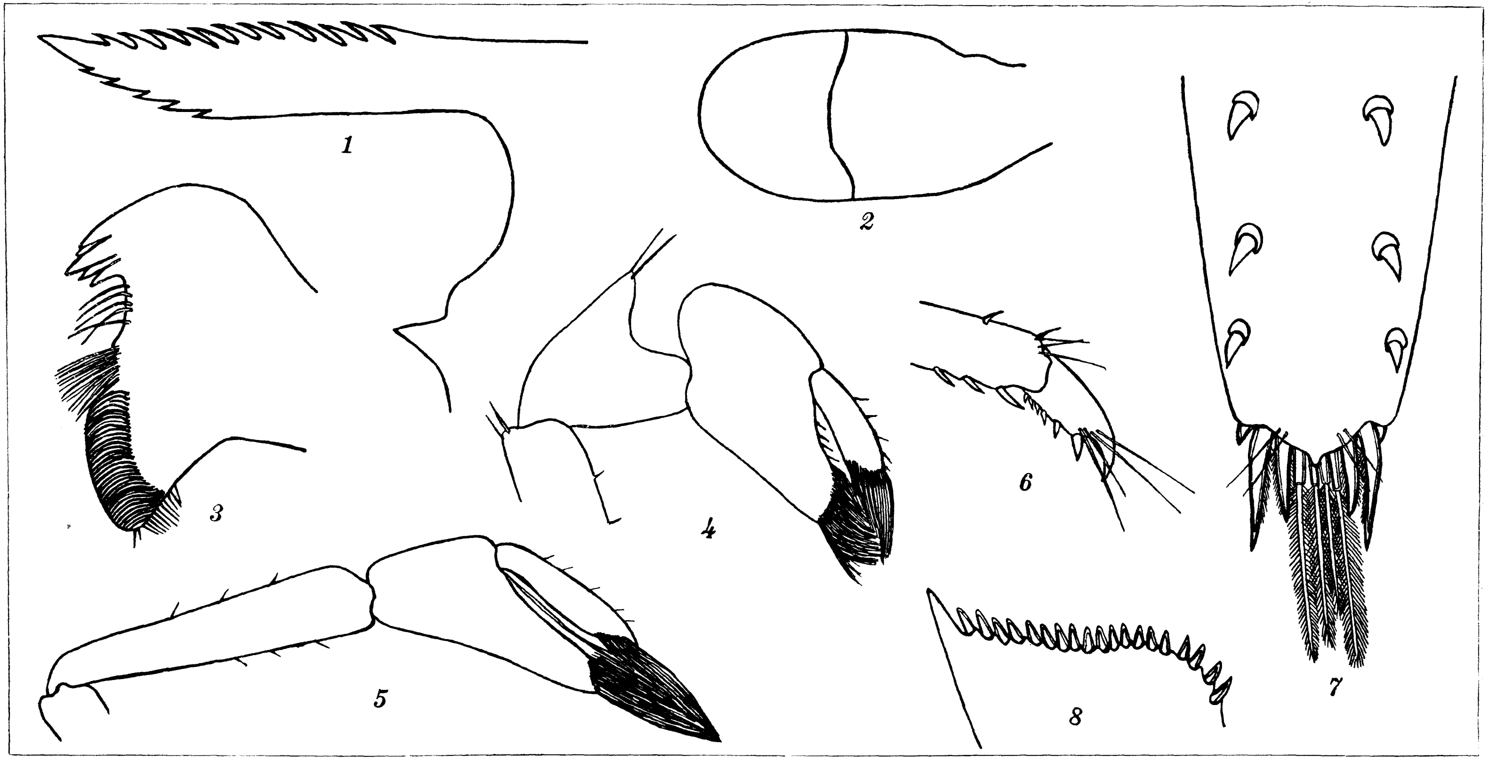


PLATE 2. CARIDINA LAOAGENSIS SP. NOV.

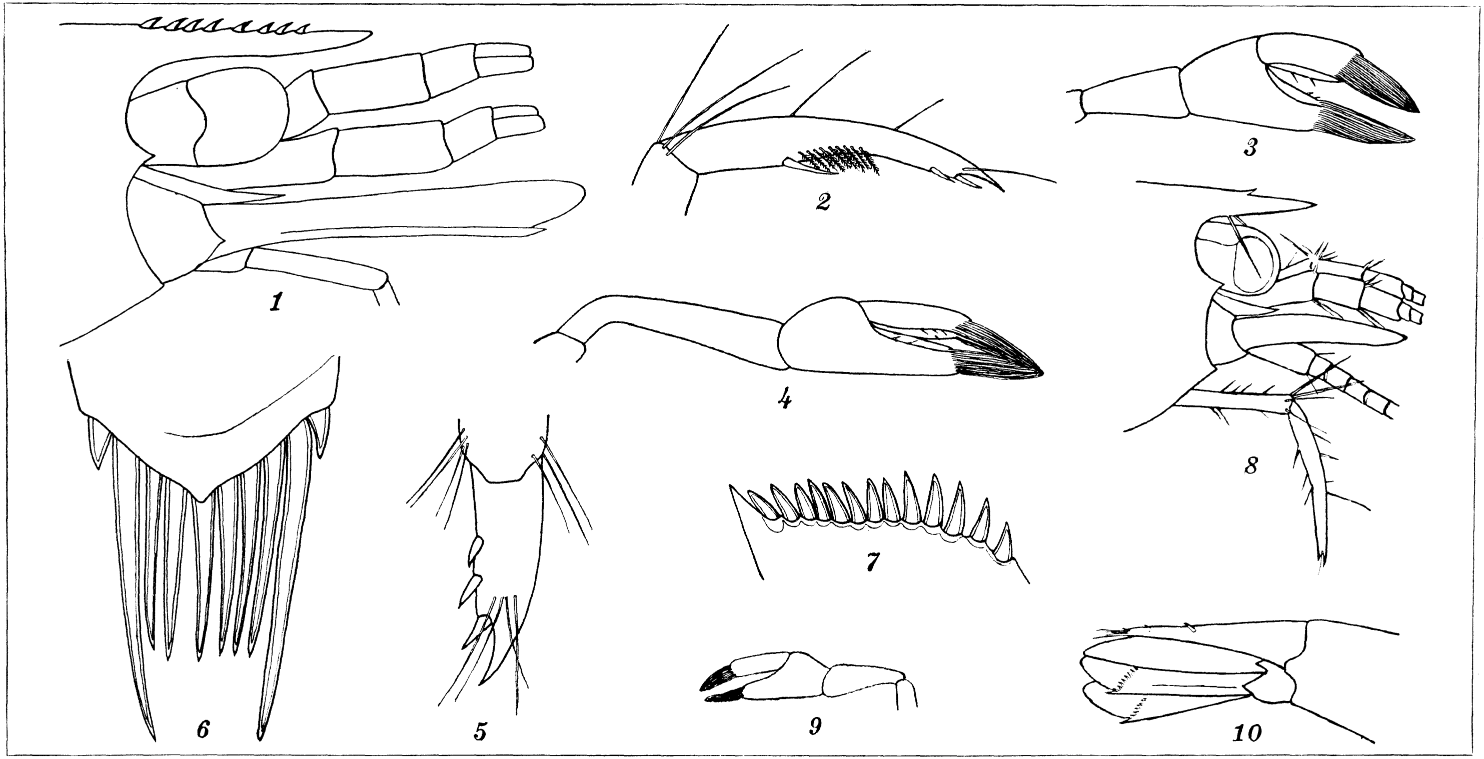


PLATE 3.

CLINOSTOMUM ABDONI SP. NOV., A TREMATODE PARASITE OF THE CAT IN THE PHILIPPINES

By MARCOS A. TUBANGUI
Of the Bureau of Science, Manila

and

EUSEBIO Y. GARCIA
Of the Institute of Hygiene, Manila

ONE TEXT FIGURE

A single specimen of this interesting parasite was recently received by one of us (E. Y. G.) from Dr. Alfredo Abdon with the information that it was obtained from a pocket under the tongue of a house cat in Surigao, Surigao Province, Mindanao. The finding of the fluke in a mammal is of more than ordinary interest, due to the fact that all of the previously described members of the genus *Clinostomum* have all been encountered in the oral cavity, pharynx, or œsophagus of fish- and frog-eating birds. It is probable that the new form is also normally a bird parasite, the cat being only an incidental host. We have the pleasure of naming the parasite after Doctor Abdon in appreciation of his interest and his courtesy in placing the material at our disposal.

Description.—Body elongate, measuring 6.8 millimeters in length by 1.65 millimeters in maximum width across middle of postacetabular region; preacetabular region more or less uniform in width. Cuticle unarmed. Oral sucker terminal, 0.30 by 0.40 millimeter, partially retracted, with the anterior body wall raised around it like a collar. Acetabulum much larger than oral sucker, 0.86 by 0.64 millimeter, at junction of anterior and middle thirds of body length. Prepharynx long, pharynx rudimentary, œsophagus practically absent; intestinal cæca with short lateral evaginations in postacetabular region, extending to near posterior end of body.

Testes tandem, small, kidney-shaped, 0.20 by 0.40 millimeter, at middle of posterior third of body length. Cirrus sac ventral to anterior testis, bottle-shaped, 0.60 by 0.19 millimeter, its neck bent acutely towards median line; cirrus sac incloses small seminal vesicle and short cirrus. Common genital pore median, immediately in front of anterior testis.

Ovary pear-shaped, 0.27 by 0.16 millimeter, slightly displaced towards right side of median line and partly overlapping posterior testis in ventral view. Shell gland as large as and beside ovary, ventral to posterior testis. Uterine sac enormously distended with eggs, 2.45 by 0.95 millimeters, occupying much of the space between acetabulum and anterior testis. Vitellaria follicular, in two broad lateral bands between acetabulum and posterior end of body, meeting anteriorly and posteriorly. Eggs thick-shelled, operculated, yellowish, none-embryonated, 100 to 109 by 60 to 64 microns.

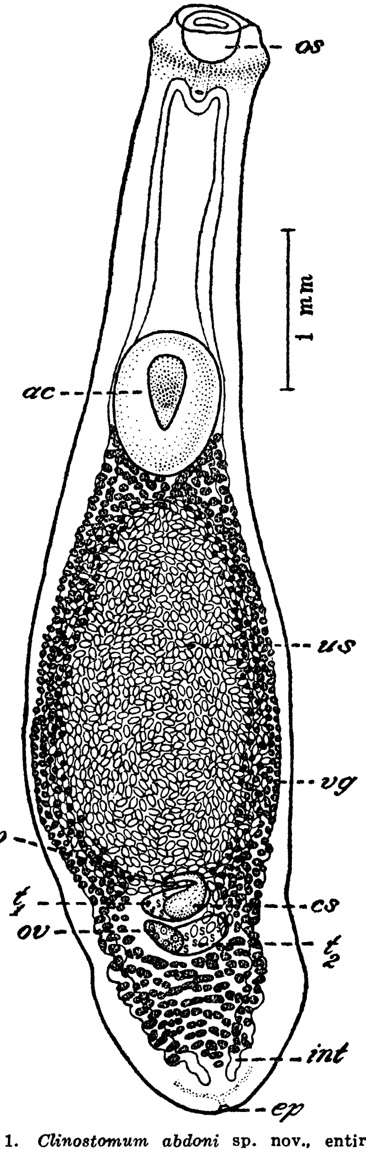


FIG. 1. *Clinostomum abdoni* sp. nov., entire worm, ventral view. *ac*, acetabulum; *cs*, cirrus sac; *ep*, excretory pore; *gp*, genital pore; *int*, intestinal cæcum; *os*, oral sucker; *ov*, ovary; t_1, t_2, testes; *us*, uterine sac; *vg*, vitelline glands.

Excretory bladder V-shaped; excretory pore terminal.

Host.—House cat (*Felis catus domesticus*).

Location.—Mouth cavity, under tongue.

Locality.—Surigao, Surigao Province, Mindanao.

Type specimen.—Bureau of Science parasitological collection No. 579.

Two species of immature clinostomes have been described from the Philippines; namely, *Clinostomum dalagi* Tubangui, 1933, from a fish, and *C. pseudoheterostomum* Tubangui, 1933, from a frog. *Clinostomum abdoni* differs very markedly from both of these forms. It appears to be more closely related to *C. lophophallum* Baer, 1933,

which was collected from the mouth of a heron, *Phoyx purpurea manillensis* (Meyer)[1] in Macassar, Celebes. It may be distinguished from its near relative by its smaller body size, the more posterior location of the main reproductive organs, the shaped of the testes, the position of the genital pore in front of the first testis, the greater development of the uterine sac, and the smaller size of the eggs.

LITERATURE CITED

BAER, J. G. Note sur un nouveau trematode, Clinostomum lophophallum sp. nov., avec quelques considerations generales sur la famille des Clinostomidae. Rev. Suisse Zool. **40** (1933) 317–342.

TUBANGUI, M. A. Trematode parasites of Philippine vertebrates, VI. Descriptions of new species and classification. Philip. Journ. Sci. **52** (1933) 167–197.

[1] The eastern purple heron also occurs in many islands of the Philippines.

ILLUSTRATION

TEXT FIGURE

[Drawing by Baldomero Escuadro.]

FIG. 1. *Clinostomum abdoni* sp. nov., entire worm, ventral view. *ac*, acetabulum; *cs*, cirrus sac; *ep*, excretory pore; *gp*, genital pore; *int*, intestinal cæcum; *os*, oral sucker; *ov*, ovary; t_1, t_2, testes; *us*, uterine sac; *vg*, vitelline glands.

DIATOMS IN THE STOMACHS OF MARINE ANIMALS FROM AMOY AND VICINITY

By T. G. Chin

Of the Marine Biological Station, University of Amoy, China

Diatoms are the grasses of the ocean and the basic food of marine animals. Therefore the study of the stomach contents, or the contents of the alimentary canals of marine animals, may yield a large number of diatoms. Diatoms are especially numerous in those small forms in which, by means of the cilia, sea water is made to circulate in and out of the body. The food-getting apparatus of this type of animal is better fitted than the finest tow net for collecting diatoms and other small organisms.

The present paper covers 12 samples, representing 11 species of animals, 9 of them invertebrates, and 2 protochordates. Eighty-eight species of diatoms were obtained from the stomachs of these animals, 24 of them new for China coast, mostly *Navicula*, 5 of them brackish-water species, and 5 fresh-water species.

Sample 1.—Collected from the small oyster, *Ostrea talienwhanensis*, Kulangsu, June, 1937. Fourteen species of diatoms were found.

Sample 2.—Collected from the small oyster, *Ostrea talienwhanensis*, Chipbee, June, 1937. Nineteen species were found.

Sample 3.—Collected from the large oyster, *Ostrea gigas*, Chuan Chow, April, 1937. Twenty-one species were found.

Sample 4.—Collected from *Solen* sp., Amoy, June, 1937. Fourteen species were found.

Sample 5.—Collected from *Pinna* sp., Nantaiwu, August and September, 1936. Twenty-one species were found.

Sample 6.—Collected from *Lingula* sp., Chipbee, April, 1937. Twenty-eight species were found.

Sample 7.—Collected from the purple sea urchin, *Heliocidaris crassispina*, Nantaiwu, April, 1936. Twenty-nine species were found.

Sample 8.—Collected from the sea cake, *Peronella lesseuri*, Chipbee, August, 1936. Twelve species were found.

Sample 9.—Collected from many species of the sea cucumber, from different localities near Amoy, 1936. Eleven species were found.

Sample 10.—Collected from the sipunculus, *Phymosoma scolops*, Amoy Harbour, spring, 1937. Seventeen species were found.

Sample 11.—Collected from amphioxus, *Branchiostomata* sp., Liuwutien, June, 1937. Thirty species were found.

Sample 12.—Collected from the purple ascidian, *Cynthia rosea*, Chipbee, June, 1936. Twenty-six species were found.

DIATOMS FOUND

MELOSIRA MONILIFORMIS (Müll.) Agardh.

Sample 1.

MELOSIRA JUERGENSI Agardh.

Sample 5.

PARALIA SULCATA (Ehr.) Cleve.

Sample 3.

HYALODISCUS SUBTILIS Bail.

Samples 2 and 3.

PODOSIRA STELLIGER (Bail.) Mann.

Samples 2, 3, 4, 5, 6, 11, and 12.

STEPHANOPYXIS PALMERIANA (Grev.) Grunow.

Sample 9.

ACTINOCYCLUS EHRENBERGI Ralfs.

Samples 2, 4, 7, 11, and 12.

ACTINOCYCLUS EHRENBERGI var. **CRASSA** (W. Sm.) Hustedt.

Sample 2.

COSCINODISCUS LINEATUS Ehrenberg.

Samples 1, 2, 3, 4, 5, 6, 7, 10, 11, and 12.

COSCINODISCUS EXCENTRICUS Ehrenberg.

Samples 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, and 12.

COSCINODISCUS SUBTILIS (Ehr.) Grunow.

Samples 1, 2, 3, 4, 7, 8, 10, and 12.

COSCINODISCUS CURVATULUS Grunow.

Samples 2, 5, 7, 8, 10, and 12.

COSCINODISCUS CURVATULUS var. MINOR (Ehr.) Grunow.

Coscinodiscus curvatulus var. *minor* (Ehr.) Grunow, HUSTEDT (1928) 409, fig. 217.

Sample 2.

COSCINODISCUS EXCENTRICUS var. FASCICULATA Hustedt.

Coscinodiscus excentricus var. *fasciculata* HUSTEDT (1928) 390, fig. 202.

Sample 2. First record for China Coast.

COSCINODISCUS STELLARIS Roper.

Coscinodiscus stellaris Roper, HUSTEDT (1928) 396, fig. 207.

Samples 2 and 3. First record for China Coast.

COSCINODISCUS STELLARIS var. SYMBOLOPHORA (Grun.) Jorgensen.

Coscinodiscus stellaris var. *symbolophora* (Grun.) Jorgensen, HUSTEDT (1928) 396, fig. 208.

Sample 2. First record for China Coast.

COSCINODISCUS RADIATUS Ehrenberg.

Samples 3, 6, 7, 8, 9, 10, and 12.

COSCINODISCUS MARGINATUS Ehrenberg.

Samples 7, 11, and 12.

COSCINODISCUS ASTEROMPHALUS Ehrenberg.

Samples 7, 9, 10, and 11.

COSCINODISCUS JONESIANUS var. COMMUTATA (Grun.) Hustedt.

Sample 8.

CYCLOTELLA STRIATA (Kütz.) Grunow.

Samples 1, 4, 5, 6, 10, 11, and 12.

CYCLOTELLA STYLORUM Brightwell.

Samples 1, 2, 3, 6, and 11.

CYCLOTELLA COMTA (Ehr.) Kützing.

Samples 2, 4, 6, 7, 10, 11, and 12.

CYCLOTELLA CHAETOCERAS Lemmermann.

Cyclotella chaetoceras Lemmermann, HUSTEDT (1928) 344, fig. 175.

Sample 3. First record for China Coast.

ARACHNOIDISCUS ORNATUS Ehrenberg.

Samples 7 and 10.

ACTINOPTYCHUS UNDULATUS (Bail.) Ralfs.

Samples 1, 3, 5, 6, 7, 9, 11, and 12.

ASTEROMPHALUS ROBUSTUS Castr.

Samples 10 and 12.

AULISCUS INCERTUS Schmidt.

Auliscus incertus Schmidt, HUSTEDT (1929) 522, fig. 296.

Sample 2. First record for China Coast.

TRICERATIUM FAVUS Ehrenberg.

Samples 3, 4, and 11.

TRICERATIUM BALEARICUM fo. **BIQUADRATA** (Janisch) Hustedt.

Triceratium balearicum fo. *biquadrata* (Janisch) HUSTEDT (1930) 813, fig. 477.

Sample 7. First record for China Coast.

TRICERATIUM BROECKII Leudiger-Fortmorel.

Triceratium Broeckii Leudiger-Fortmorel, HUSTEDT (1930) 802, fig. 465.

Sample 11. First record for China Coast.

ACTINOPTYCHUS ANNULATA (Wall.) Grunow.

Samples 1, 4, 5, 6, 7, 10, 11, and 12.

BIDDULPHIA MOBILIENSIS (Bail.) Grunow.

Sample 1.

BIDDULPHIA AURITA (Lyn.) Brebisson.

Sample 2.

BIDDULPHIA AURITA var. **OBTUSA** (Kütz.) Hustedt.

Sample 3.

BIDDULPHIA PULCHELLA Gray.

Samples 7 and 11.

BIDDULPHIA OBTUSA Kützing.

Samples 7 and 10.

RAPHONEIS AMPHICEROS Ehrenberg.

Samples 5 and 6.

SYNEDRA GALLIONII Ehrenberg.

Samples 4, 9, and 12.

SYNEDRA TABULATA (Ag.) Kützing.

Sydnedra tabulata (Ag.) Kützing, VAN HEURCK (1896) 314, pl. 10, fig. 431.

Sample 5. First record for China Coast.

SYNEDRA ULNA Ehrenberg.

Synedra ulna Ehrenberg, VAN HEURCK (1896) 310, pl. 10, fig. 409.

Sample 6. Fresh-water species.

SYNEDRA ROBUSTA Ralfs.

Synedra robusta Ralfs, VAN HEURCK (1896) 316, pl. 30, figs. 836, 837.

Sample 7. First record for China Coast.

RHABDONEMA ADRIATICUM Kützing.

Sample 7.

GRAMMATOPHORA MARINE var. MACILENTA van Heurck.

Samples 7 and 8.

ACHNANTHES BREVIPES Agardh.

Samples 5, 7, and 9.

COCCONEIS SCUTELLUM Ehrenberg.

Samples 1, 5, and 7.

COCCONEIS DISRUPTA Greg.

Sample 7.

NAVICULA FUSCA (Greg.) Ralfs.

Navicula fusca (Greg.) Ralfs, DONKIN (1870) 7, pl. 1, fig. 5.

Sample 1. First record for China Coast.

NAVICULA INTERRUPTA Kützing.

Samples 1, 4, 5, and 6. Brackish-water species.

TRACHYNEIS ASPERA Ehrenberg.

Samples 2, 3, 5, 6, 7, 11, and 12.

NAVICULA CRABRO Ehrenberg.

Samples 3, 6, 7, 8, 11, and 12.

NAVICULA ELLIPTICA Kützing.

Navicula elliptica Kützing, DONKIN (1870) 7, pl. 1, fig. 6.

Samples 4, 5, 6, 9, 10, 11, and 12. First record for China Coast. Brackish-water species.

NAVICULA BOMBUS (Ehr.) Kützing.

Navicula bombus (Ehr.) Kützing, DONKIN (1870) 50, pl. 7, fig. 7.

Sample 5. First record for China Coast. Brackish-water species.

NAVICULA LITORALIS Donkin.

Navicula litoralis DONKIN (1870) 5, pl. 1, fig. 2.

Samples 6 and 10. First record for China Coast.

NAVICULA LYRA Ehrenberg.

Navicula Lyra Ehrenberg, DONKIN (1870) 14, pl. 2, fig. 7.

Samples 6 and 11. First record for China Coast.

NAVICULA NITESCENS Greg.

Navicula Nitescens Greg., DONKIN (1870) 8, pl. 1, fig. 7.

Samples 6 and 11. First record for China Coast.

NAVICULA FORTIS Greg.

Sample 6.

NAVICULA SCOPULORUM Brebisson.

Navicula scopulorum Brebisson, DONKIN (1870) 73, pl. 12, fig. 5.

Samples 6 and 7.

NAVICULA FORCIPATA Greville.

Navicula forcipata Greville, DONKIN (1870) 12, pl. 2, fig. 4.

Sample 9. First record for China Coast.

NAVICULA LONGA Greg.

Sample 11.

NAVICULA DIRECTA W. Sm.

Sample 11.

NAVICULA ABRUPTA Greg.

Sample 11.

PINNULARIA TABELLARIA Ehrenberg.

Pinnularia Tabellaria Ehrenberg, DONKIN (1870) 70, pl. 12, fig. 4.

Sample 6. Fresh-water species.

TRACHYNEIS CLEPSYDRA (Donkin) Cleve.

Trachyneis Clepsydra (Donkin) Cleve, DONKIN (1870) 63, pl. 10, fig. 2.

Samples 11 and 12. First record for China Coast.

GOMPHONEIS GRACILE Ehrenberg.

Gomphoneis gracile Ehrenberg, VAN HEURCK (1896) 272, pl. 7, fig. 309.

Sample 1. Fresh-water species.

CYMBELLA ASPERA (Ehr.) Cleve.

Sample 4. Fresh-water species.

CYMBELLA ASPERA var. MINOR van Heurck.

Cymbella aspera var. *minor* VAN HEURCK (1896) 146, pl. 1, fig. 36.

Samples 3 and 4. Fresh-water species.

AMPHORA SALINA W. Sm.

Samples 5 and 6. Brackish-water species.

AMPHORA COMMUTATA Grunow.

Amphora commutata Grunow, VAN HEURCK (1896) 132, pl. 1, fig. 13.

Sample 11. First record for China Coast.

PLEUROSIGMA NORMANII Ralfs.

Samples 2, 3, 5, 6, 9, 10, 11, and 12.

PLEUROSIGMA PELAGICUM Peragallo.

Pleurosigma pelagicum Peragallo, ALLEN & CUPP (1935) 157, fig. 104.

Samples 6, 11, and 12. First record for China Coast.

PLEUROSIGMA AFFINE Grunow.

Pleurosigma affine Grunow, VAN HEURCK (1896) 252, pl. 6, fig. 263.

Samples 7 and 8.

PLEUROSIGMA NAVICULACEUM Brebisson.

Samples 8, 11, and 12.

GYROSIGMA BALTICUM W. Sm.

Samples 2 and 3.

SURIRELLA FLUMINENSIS Grunow.

Samples 1, 3, 5, 7, 9, 10, and 11.

SURIRELLA SPIRALIS Kützing.

Surirella spiralis Kützing, VAN HEURCK (1896) 374, pl. 13, fig. 592.

Sample 3. First record for China Coast.

SURIRELLA GEMMA Ehrenberg.

Samples 6 and 8.

SURIRELLA VOIGTII Skvortzow.

Surirella voigtii SKVORTZOW (1932) 160, pl. 1, figs. 1 to 3; pl. 2, fig. 1.

Samples 8 and 10.

CAMPYLODISCUS HODGSONII W. Sm.

Sample 7.

CAMPYLODISCUS (?) COCCONEIFORMIS Grunow.

Samples 3, 5, 7, 10, 11, and 12.

NITZSCHIA LANCEOLATA W. Sm.

Nitzschia lanceolata W. Sm., VAN HEURCK (1896) 400, pl. 17, fig. 548.

Samples 1 and 6. First record for China Coast. Brackish-water species.

NITZSCHIA PUNCTATA (W. Sm.) Grunow.

Samples 5, 6, 7, 9, 11, and 12.

NITZSCHIA PUNCTATA var. ELONGATA van Heurck.

Nitzschia punctata var. *elongata* VAN HEURCK (1896) 385, pl. 15, fig. 492.

Sample 8. First record for China Coast.

NITZSCHIA FASCICULATA Grunow.

Nitzschia fasciculata Grunow, VAN HEURCK (1896) 397, pl. 16, fig. 536.

Sample 12. First record for China Coast.

NITZSCHIA LONGISSIMA (Breb.) Ralfs.

Sample 12.

BACILLARIA PARADOXA (Gmel.) Grunow.

Sample 12.

GOMPHONITZSCHIA CHINENSIS Skvortzow.

Gomphonitzschia chinensis SKVORTZOW (1932) 159, pl. 3, fig. 1.

Sample 6.

STICTODESMIS AUSTRALIS Greville.

Stictodesmis Australis Greville, VAN HEURCK (1896) 236, fig. 34.

Sample 8. First record for China Coast.

A METHOD FOR DEGUMMING AND BLEACHING DECORTICATED RAMIE FIBER

By MARIANO P. RAMIRO
Of the Bureau of Science, Manila

Decorticated ramie is a gummy bast fiber of the ramie plant (*Boehmeria nivea* L.), debarked and separated from the woody portion by a decorticating machine. It is often called China grass, ramie ribbon, or simply ramie. Locally the plant is known as *lipang aso* (Tag.). If purified properly its strong fibers become lustrous like silk, and suitable for the manufacture of high-grade textiles. Since the production of ramie is a growing industry, it would seem important to develop an economical and effective method for degumming decorticated ramie grown in the Philippines.

Ramie was the source of textile fiber in the early Egyptian dynasties, and since that time it has been rediscovered several times. The early Chinese wove fiber from ramie into a delicate, beautiful "grass cloth." Today other oriental countries are using it for the same purpose as well as in the manufacture of cordage.

The ramie plant is a "cluster of tuberous roots(8) surrounded by a mass of fleshy rootlets, supporting a growth of from 10 to 80 stalks which shoot upward to a height of from 4 to 8 feet." The stalks vary in diameter from five-sixteenths to three-fourths of an inch at maturity. The leaves of ramie are ovate-acuminate, green on the upper surface, and hairy and silvery or whitish beneath. The bast fibers are imbedded in the bark that surrounds the woody portion of the tree.

For years the inhabitants of the Batanes Islands and the non-Christian people of northern Luzon have cultivated and extensively used ramie for various purposes.

The plant was introduced into Davao from Formosa in 1931 by the Ohta Development Company. It has been reported(4) that six crops can be obtained annually in Mindanao. Under normal conditions a hectare of ramie in Davao yields forty piculs of decorticated fiber. The cost of producing a picul of the fiber

in Davao is estimated at 12 pesos.[1] At this rate it would mean a net profit of 18 pesos per picul to producers, since the current price of one picul is 30 pesos.

In other ramie-producing countries (Table 1) the planters can obtain only from one to four crops a year. It thus appears that the ramie industry in the Philippines has advantages and possibilities over such an industry in other countries.

TABLE 1.—*Annual yield of decorticated ramie fiber, in pounds per hectare.*

Countries.	Number of cuttings.	Pounds per hectare.
Philippines (Calinisan)	6	[a] 5,340
Algiers (Hardy)	3	[b] 8,150
California (Hilgard)	2–4	[b] 4,000
France (Favier)	3	[b] 3,300
India (Spon)	2	[b] 1,250
Italy (De Mass)	2	[b] 2,800

[a] Figures taken from Calinisan. [b] Figures taken from Dodge.

Calinisan states that in 1936 there were four plantations in Davao, comprising 176 hectares, of which 100 hectares belong to the Ohta Development Company, 50 hectares are credited to the Catalunana Agricultural Company, 20 hectares are registered under the Furukawa Plantation, and 6 hectares are developed by the Pendisaan Plantation.

According to Lomat,(11) the Ohta and Furukawa Companies in the early part of 1938 owned over 300 hectares of ramie, and exported 600 piculs of decorticated ramie to Japan.

Degummed China grass is glossy and looks almost like silk. This property of the fiber, combined with its strength which is eight times that of cotton,(5) makes ramie a valuable material for the manufacture of textiles and paper. The degummed fiber is also a source of alpha cellulose that may be converted into artificial silk and other products. The purified filaments have been woven into a variety of goods, such as table cloths, napkins. curtains, dress goods, and knit materials.(12)

In Europe, particularly France, Germany, and England, ramie is used for linen,(9) drawn-work doilies, and other textile goods.(7) In the paper industry ramie pulp is known as an excellent material for bank notes(10) and writing paper of high quality.

[1] One peso equals 50 cents United States currency.

Spun ramie fiber has been made into incandescent mantles(1) superior to those made of cotton.

PREVIOUS WORK ON DEGUMMING

To render ramie suitable for the manufacture of high-grade textiles or of substitutes for textile materials, it has to be economically degummed. Several methods for degumming the fiber have been reported in literature.(3, 5, 6, 13, 14)

As a result of numerous preliminary experiments there was developed in this laboratory a method that seems to be very suitable for local conditions.

EXPERIMENTAL PROCEDURE

Analytical.—For industries that use fibrous plants as their basic raw material, the composition of the plant is a matter of considerable importance. In general the results of analyses give an idea of the quality of the fiber, and also the properties of the incrusting substances. A knowledge of these components is essential in refining the fiber.

A quantitative determination was made of the different constituents of the raw material and of the purified fiber. For the former (Table 3) the sample was extracted with alcohol-benzol, followed in succession by cold-water extraction and a digestion with 1 per cent sodium hydroxide. The total cellulose was determined from the residue. In another case, for each component of the raw material determined, a different original sample was used.

In the analysis of the purified fiber the standard method used by the Forest Products Laboratory(2) of the United States department of Agriculture was adopted.

Degumming.—The fiber was digested in 2 stages of 1.5 hours each, in a dilute solution of caustic soda or a mixture of dilute solution of caustic soda and ammonium carbonate in the first stage, and a combination of caustic soda and sodium sulphite in the second. The proportions of the chemicals used for digestion are shown in Table 10, in which experiments 27 and 28 gave the best results. The total volume of cooking liquor used for every 36 grams of oven-dry fiber is approximately 400 cubic centimeters.

Bleaching.—Sodium hypochlorite was used in bleaching the degummed fiber. Twenty-seven grams of the fiber was placed in a suitable container with 400 cubic centimeters of water heated to 40° C. The sodium hypochlorite solution containing 22 grams per liter of available chlorine was added, with constant stirring so that it mixed well with the fiber. The container, which was frequently shaken, was placed in a bath of 40° C. and maintained at this temperature until the bleaching liquor was completely exhausted. The fiber was then carefully washed and dried.

Softening.—To render the degummed ramie soft and flexible, it was treated for 1 to 2 hours with an emulsion consisting of soap solution and kerosene. Before drying, the emulsion was either partially or completely washed out with tap water.

RESULTS

Analysis.—The difference observed in the cellulose content of the decorticated and the undecorticated fiber (Tables 2 and 3) is to be expected, because the bark which is intact in the undecorticated material dissolves readily in the process of analysis.

TABLE 2.—*Total cellulose from undecorticated fiber.*[a] *(Cross and Bevan method.)*

Sample No.	Weight of material used. [b]	Cellulose.	
	g.	*g.*	*Per cent.*
1	2.1192	.9910	46.70
2	1.7940	.9132	50.80
3	1.7940	.9450	52.65
4	1.7940	.9472	52.75
Average			50.72

[a] Samples in this determination were grown in Manila. [b] Oven dry.

TABLE 3.—*Composition of decorticated ramie fiber, calculated on dry weight.*

Composition.	Per cent.
Cellulose (ash free)	83.51
Alcohol-benzol extract	2.15
Cold-water soluble	3.57
Alkali soluble	9.95
Ash (in cellulose)	0.21

The decorticated fiber does not give any reaction for ligneous bodies. The absence of such bodies perhaps accounts for the rapid isolation and purification of the fiber. Alcohol and alcohol-benzol extracts are small (Table 4), indicating the resistance of the gum to the action of organic solvents. The relative difference in the ash content of the untreated and the treated fiber (Tables 3 and 4, respectively), shows that the mineral constituents are readily dissolved during the isolation of the cellulose. More or less complete elimination of the mineral components during the degumming and bleaching processes is further disclosed by the small difference in the ash content of the fiber purified by the Cross and Bevan method, and the alpha cellulose shown in Tables 3 and 5, respectively.

TABLE 4.—*Constituents and extract of decorticated fiber, determined separately from original individual sample.*

Component.	Method used.	Per cent.
Cellulose	Chlorination	84.15
Alcohol extract	Soxhlet extraction	2.53
Alcohol-benzol extract	do	2.15
Hot-water soluble	Reflux with H_2O for 1 hr.	3.14
Cold-water soluble	Digestion with distilled H_2O for 48 hours	2.29
Alkali soluble	Digestion with 1% NaOH for 1 hour	15.46
Moisture	Oven drying at 105°C	9.70
Ash	Obtained by incineration from untreated sample	4.05

TABLE 5.—*Analysis of degummed ramie fiber compared with that of commercial rayon pulp.*

Material.	Alpha cellulose.	Ash.	Soluble in 10 per cent KOH.	Copper number.	Beta and gamma cellulose.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*
Degummed ramie fiber	96.01	0.11	4.24	0.79	[b] 3.88
Highly purified wood pulp [a]	95.08	0.08	5.45	1.04	
Rayon pulp now on the market [a]	87.76	0.12	11.39	1.93	

[a] Schwarz, E. W. K., and H. R. Mauersberger, Rayon and Synthetic Yarn Handbook (1936) 53.
[b] Estimated by difference.

Digestion.—A comparative study of all the experiments recorded in Tables 6, 7, 8, 9, and 10 indicates that the concentration of the cooking liquor has some effect on the digestion yield. The average yield of the samples treated with a relatively strong solution (in the first and second digestion, Table 6) is

TABLE 6.—*Two-stage digestion, each followed by bleaching.*

Sample No.	Materials used (oven dry).	1st digestion.		Color of bleached fiber.[a]	2d digestion.				Bleach, NaOCl.[b]	Color of bleached fiber.	Yield.
		NaOH, 1 per cent solution.	Time.		NaOH, 1 per cent solution.	Na_2SO_3 2 per cent solution.	$(NH_4)_2CO_3$.	Time.			
	g.	*cc.*	*Hrs.*		*cc.*	*cc.*	*g.*	*Hrs.*	*cc.*		*Per cent.*
1	27.51	400	1.0	gray	200	300		2.0	10	grayish	75.80
2	30.67	400	1.0	yellowish		360		1.5	10	white	73.30
3	36.24	450	1.0	gray		400	3	1.5	10	fairly white	73.70
4 [c]	36.60	400	1.5	do	100	400	3	1.5	8	do	66.00
5	34.80	400	1.5	light brown	100	400	4	1.5	8	do	73.50
6	35.72	400	1.5	brownish		200		1.3	8	yellowish	70.30
7	35.72	400	1.5	do		200	4	1.5	8	do	70.00
8	35.72	400	1.3	light brown		200	4	1.5	8	do	69.20
9	35.72	400	1.3	brownish		200	3	2.0	8	do	71.00
10	36.00	200	1.5	do		200	3	1.5	8	do	74.45
11	36.00	200	1.5	gray		200	4	1.5	8	do	73.65

[a] Five cc bleach liquor containing 22 grams available chlorine per liter was used.
[b] Contains 22 grams available chlorine per liter.
[c] This sample was moldy.

TABLE 7.—*Effect of water pretreatment on the degumming of 36 grams* [a] *of ramie fiber.*

[Bleach used: 5 cc sodium hypochlorite.[b]]

Sample No.	Time.	Color change.	Yield.
	Hrs.		*Per cent.*
12	7	none	95.60
13	7	do	95.67
14	22	slightly bleached	94.62
15	22	do	94.82

[a] Oven dry.
[b] Contains 22 grams available chlorine per liter.

TABLE 8.—*Degumming of ramie fiber, 1st digestion.*[a]

[Sodium hydroxide, 200 cc 1 per cent solution. Bleach used, 15 cc sodium hypochlorite.[b]]

Sample No. [c]	$(NH_4)_2CO_3$.	Color of bleached fiber.	Yield.
	g.		*Per cent.*
12	4	yellow	86.40
13	5	do	87.05
14		yellowish	78.70
15	8	do	79.72

[a] All digestions were made in 2 hours.
[b] Contains 22 grams available chlorine per liter.
[c] Products from water pretreatment were used.

TABLE 9.—*Degumming of ramie fiber, 2d digestion.*[a]

[Bleach used: 7 cc sodium hypochlorite.[b]]

Sample No. [c]	NaOH, 1 per cent solution.	Color of bleached fiber.	Yield.
	cc.		*Per cent.*
12	50	yellow	79.80
13	50	do	80.35
14	50	slightly yellowish	75.60
15	25	yellowish	76.37

[a] All digestions were made in 1.5 hours.
[b] Contains 22 grams available chlorine per liter.
[c] Products from first digestion were used.

TABLE 10.—*Two-stage digestion*[a] *followed by one-stage bleaching.*

[Thirty-six grams (oven dry) of material were used in all samples.]

Sample No.	1st digestion, NaOH, 1 per cent solution.	Second digestion.			Bleach NaOCl.[b]	Color of bleached fiber.	Yield.
		NaOH, 1 per cent solution.	Sodium sulphite, 2 per cent solution.	$(NH_4)_2$-CO_3.			
	cc.	*cc.*	*cc.*	*g.*	*cc.*		*Per cent.*
18	50	-------	50	-------	10	yellowish	79.50
19	50	50	-------	-------	10	do	78.70
20	300	25	-------	-------	8	fairly white	74.80
21	250	75	-------	-------	8	do	73.42
22	150	50	50	3	8	some fiber unbleached	78.05
23	200	50	50	3	8	streaky with unbleached fiber	75.35
24	50	50	50	3	8	poorly bleached	79.82
25	100	50	50	3	8	unbleached	78.20
26	350	50	50	3	5	yellowish	75.03
27	400	50	50	3	5	lustrous white	73.90
28	370	50	25	-------	5	do	73.97
29	350	-------	50	-------	7	streaky	-------
30	350	-------	-------	6	7	slightly yellowish	76.58
31	300	water	water	-------	7	yellowish	77.28
32	300	40	-------	-------	7	do	76.43
33	200	100	100	-------	7	white	74.21
34	200	100	50	-------	7	fairly white	75.30

[a] All digestion lasted 1.5 hours.
[b] Contains 22 grams available chlorine per liter.

definitely lower than the yield of the samples (Tables 7, 8, 9, and 10) treated with a cooking solution of moderate concentration. Since digestion and bleaching in all cases took place under uniform conditions, the difference in yield must be due to the concentration of the cooking liquor. This observation agrees with the usual experience in the digestion of fibrous material; that is, the stronger the liquor, the lower the yield, other conditions being equal.

When the product was treated with acid, the best results in yield and bleach requirements were obtained under the following conditions: The cooking liquor for the first digestion should have 9.25 grams of sodium hydroxide per liter. The solution for the second digestion, consisting of a mixture of sodium sulphite and caustic soda, should contain 1.25 grams per liter each.

An increase in the ratio of the digestion chemical to the fiber did not seem to improve the bleach consumption of the product. This is shown in samples 6, 7, 8, 9, 10, and 11 in Table 6, and the samples in Tables 7, 8, and 9 in which the fiber was not treated

with a dilute acid. It would seem, therefore, that the purification of the fiber is not dependent entirely on the strength of the cooking solution.

In experiments in which dilute acid was used, the bleach requirements of the fiber were small in comparison with the bleach demand for samples (Tables 6, 7, 8, and 9) having no acid treatment. In almost all cases the bleach demand of the samples in Tables 6, 7, 8, and 9 was about three times the amount of bleach used in samples 27 and 28 (Table 10) which were washed with the acid after digestion or before bleaching.

Under these conditions it is obvious that the acid treatment has a definite function. It dissolves a major portion of the mineral matter serving as lakes for the dyes, gums, and other impurities of the fiber. Consequently the impurities are rendered washable and the dyes are left exposed favorably to the attack of the bleaching agent.

Ammonium carbonate may be left out when the fiber is digested under atmospheric pressure. Results (Tables 6 and 10) reveal that a sample digested with a solution containing ammonium carbonate does not differ in yield and bleach requirement from another sample cooked without carbonate. It is obvious that the compound has no effect in the degumming of ramie under ordinary pressure, hence it may be omitted.

Pretreating (soaking) the raw material with cold water for 22 hours does not in any manner help in the removal of the gum, as Tables 7, 8, and 9 indicate. Approximately 5 per cent of the weight of the fiber was lost in the cold-water digestion. Any effect this pretreatment may have appeared to be negative, judging from the large amount of bleaching solution required to give the product a desirable degree of whiteness. That the impurities of ramie fiber are insoluble in water is to be expected, since the major portion of these impurities constitute gummy substances which do not dissolve in water.

Softening.—It was experienced that although the fiber is well purified, as in the case of samples 27 and 28 (Table 10), on drying the fiber becomes hard and stiff, due, possibly, to the residual gum which is resistant to the action of the cooking and bleaching liquors. Under these conditions, the fiber is not fitted for spinning.

To render the fiber soft without inflicting injury to it, is highly important. This is made possible by treating the purified fiber

from one to two hours with an emulsion of soap solution and kerosene.

The reaction of the emulsion toward the residual gum seems to be complex in nature. It is probable that the kerosene in the emulsion acts as a solvent for the gum. When the soluble gum is removed by washing, the treated fiber after drying is very soft and silky.

SUMMARY

1. From all indications ramie should be a profitable industry for the Philippines. There are now several plantations in Mindanao producing approximately 20,000 piculs of ramie ribbon annually.

2. Ramie fiber properly degummed is lustrous and looks almost like silk. The purified filasse could probably be industrialized into a profitable Philippine textile industry.

3. The degumming process developed in this work is considered effective and economical. Digestion of the fiber under pressure is not necessary. The time needed for purification is short.

4. The purified fiber has a high alpha cellulose content, showing that the process has little hydrolytic effect on the fiber during cooking.

LITERATURE CITED

1. BÖHM, C. R. Der Ramie-Glühkörper. Chemiker Zeitung **33** (1909) 447.
2. BRAY, M. W. Chemical analysis of pulp and woods. Paper Trade Journal (25) **87** (1928) 59–68.
3. BURTON, G. D. Preparing degummed flax, hemp, ramie, jute or sisal fibers for spinning. U. S. Patent No. 1, 116,343 (November 3, 1915).
4. CALINISAN, M. R. First hand information about ramie. Agriculture and Industrial Monthly (4) **4** (1937) 25.
5. CARTER, G. L., and P. M. HORTON. Ramie. Louisiana State Univ. Studies No. 26 (1936).
6. CARTER, G. L., and P. M. HORTON. Debarking and degumming ramie by chemical means. Industrial and Engineering Chemistry (10) **24** (1932) 1162–1163.
7. DEWEY, LYSTER H. Ramie, a fiber-yielding plant. Miscellaneous Circular No. 110. U. S. Department of Agriculture (May, 1929).
8. DODGE, C. R. Facts concerning ramie. U. S. Dept. Agriculture Yearbook (1894) 443–460.

9. DODGE, C. R. A report on the cultivation of ramie in the U. S. Report No. 7 U. S. Dept. of Agriculture. Fiber Investigations (1895).
10. FAST, A. Ramie and kendir. Bull. Gosnak (U.S.S.R.) No. 1 (1923) 10. Cited in Chemical abstracts **18** (1924) 1569.
11. LOMAT, V. Memorandum to the Director of the Bureau of Commerce (Philippines) March 17, 1938.
12. REYES, F. A. Ramie fiber may be added to Philippine industrial materials. The Philippines (9) 2 (1919) 17.
13. VERGÉ, A. E. Bleaching and degumming cotton, ramie and other vegetable fibers. French Patent No. 385,365 (March 11, 1907).
14. WEISS, R. The degumming of ramie. Bull. Soc. Ind. Mulhouse **86** (1920) 404, 405.

BOOKS

Books reviewed here have been selected from books received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEWS

Synthetic Resins and Allied Plastics. By R. S. Morrell in Collaboration with T. Hedley Barry, R. P. L. Britton and H. M. Langton. London, Oxford University Press, 1937. 417 pp., illus. Price, $11.

This book gives an excellent account of synthetic resins and of their preparation and properties. It contains many excellent suggestions for laboratory and factory practice. Good descriptions are given, with illustrations, of the machinery used in making commercial products from synthetic resins and thermoplastic materials.

Some of the more important subjects discussed are the following: molding resins of the bakelite and urea types; molding resins and plastics derived from casein and cellulose; manufacture and technique employed in molding; vinyl, styrene, acrolein, acrylic acid, coumarone, indene, and glyptal resins; resins in varnish and enamel manufacture; identification and testing synthetic resins.

Written in a clear and concise manner and giving a great deal of technique information along this line, this book is an excellent text and reference on synthetic resins.—A. P. W.

Teachable Moments. A New Approach to Health. By Jay B. Nash. New York, A. S. Barnes and Company, 1938. 244 pp. Price, $1.50.

The author brings out an interesting and novel way of making a person health conscious. While many sound and accepted principles of health practices are incorporated in the book, there are personal idiosyncracies quite contrary to present teaching and scientific precepts.

In the chapter on "Truth and Part-Truths" the author seems to have seen more of the bad than of the good sides of many practices adopted in our public schools. If he had worked as a health officer in the schools, his field of vision would have been broader.—I. F.

Nature Study Above and Below the Surface. A Bridge Between Amateur and Professional. By H. C. Gunton. With a Preface by Dr. C. B. Williams. London, H. F. & G. Witherby, Ltd., 1938. 134 pp., illus. Price, 7s/6d.

The aim of the author in presenting this book is to stimulate the interest of those who wish to obtain more than mere superficial knowledge of some of the phenomena of natural life, which are at present engaging the attention of many workers, both professional and amateur. The book embodies the author's long years of experience as a keen amateur naturalist. The author is the present Director of the Phenological Report of the Royal Meteorological Society in Great Britain, a body composed of amateurs and professionals.

The aspects of natural life under ecology and phenology and other topics are dealt with in the introduction. Outstanding phenomena in nature, like natural protection, protective resemblance to surroundings, mimicry, variation, migration, and other phases of life are discussed in the second chapter. Notable examples of the work of professional entomologists in the control of noxious insects and plants are included in a chapter on applied entomology. In the last chapter the author makes several conclusions and recommendations.—S. R. C.

Soilless Growth of Plants. Use of Nutrient Solutions, Water, Sand, Cinder, Etc. By Carleton Ellis and Miller W. Swaney. New York, Reinhold publishing corporation, 1938. 155 pp., front., illus. Price, $2.75.

This book gives a detailed description of the three recognized modifications of soilless growth, namely, water culture, sand culture, and subirrigation system.

Numerous household experiments and large-scale soilless-growth operations are discussed, and supplemented by drawings and photographs. The discussions and even the preparation of nutrient formulas are given in a popular style which can easily be understood by the layman. The authors are optimistic about the future of soilless-growth technique in plant cultivation.

—H. S. S.

The Vegetable Growing Business. By Ralph L. Watts and Gilbert Searle Watts. New York, Orange Judd Publishing Company, Inc., 1939. 549 pp., front., illus. Price, $3.50.

The unique rôle now occupied by vegetables in the diet of the people has made vegetable growing one of the most important branches of modern agriculture. Among the most recent addi-

tions to vegetable literature the book entitled "The Vegetable Growing Business," by Ralph L. Watts and Gilbert S. Watts, commands attention. The senior author is a renowned professor and an authority on vegetable growing, while the junior author is a successful commercial vegetable grower. In this volume therefore, are combined the technical knowledge of a professor and the practical experiences of a grower.

The book is divided into 25 chapters and a list of references at the end. It is profusedly illustrated. The first 12 chapters are devoted to a discussion of the general outlook of the industry, locations and soils, seeds, management, fertilizers, planting and cultivation, pests and diseases and their control, harvesting, storage, and marketing. The rest of the book is a detailed discussion of the cultures of the different groups of vegetables.

This book should be a good reference to both teachers and students of vegetable growing as well as to those actually engaged in or contemplating to engage in commercial growing of vegetables, particularly vegetables adapted to a temperate climate.—P. A. R.

Sheet Metal Work. By William Neubecker. Chicago, American Technical Society, 1938. 360 pp., illus. Price, $2.50.

This is a work-type description of sheet metal work that is used in modern buildings and in manufacturing processes. The first part of the book and a few subsequent portions thereafter are devoted to principles the understanding of which requires a knowledge of geometrical principles: areas, surfaces, and the progressive development of complex surfaces. The development of patterns, like joints of cylindrical, conical, and spherical surfaces, are described. Joints of hexagonal and square forms are also explained.

Definite problems of actual construction, as the construction of cornices, skylights, roofs, flumes, and tube elbows, are taken up. The process used in the making of moulds for terra cotta or cement mouldings is described in detail. In order to help the sheet metal worker and designer, complete tables of sheet metal properties are given. These are distributed throughout the book and placed close to each subject matter which each supplements.

With the rapid progress of manufacturing industries, pressed metal manufacturing, building construction, air conditioning, and other trades requiring the use of sheet metal, the book is indispensable as a text and guide.—G. J. S.

Methods of Tissue Culture. By Raymond C. Parker. With a Foreword by Alexis Carrel. New York, Paul B. Hoeber, Inc., 1938. 292 pp., front., illus. Price, $5.

Although the author in his preface makes it clear that the book is intended for both those who are not acquainted with the more recent developments in tissue culture and others who have never handled this work, an effort is made to orientate the reader in the extensive literature regarding various technics followed by leading researchers on the subject. Chapter XVI, for example, contains examples of the way in which the methods have been used in five important fields of investigation; namely, experimental morphology, the study of tumors and viruses, and hypersensitivity and immunity. The book includes a bibliography of supplementary references to experiments on this and other investigations not taken up in the text.

In a lengthy foreword the celebrated surgeon of the Rockefeller Institute, Dr. Alexis Carrel, who, years ago, took up seriously the work of tissue culture begun by Harrison in 1907, summarizes the importance of tissue culture in biology, to wit: "For the first time in the course of their history, biological techniques are capable of separating the living body into minute parts without destroying the life of those parts." In the beginning of the foreword he states thus, "Along with the inoculation of the dissection of the living or dead bodies and that of the microscopical examination of organs, the creation of the method of tissue culture is the most important event in the history of anatomy." In other words, tissue culture technics have made possible the study of living tissue cells and organs detached from the living body.

The author gives a brief history of tissue culture. Without the necessity of discussing the text chapter by chapter, the entire work represents, in abridged form, all the essential elements of successful methods of tissue culture. The subject as presented can easily be understood by a technical neophyte equipped with certain laboratory training and guidance. The presentation of the various types of cultivation in vitro of the different tissues of the body is sufficiently clear to make it workable. The application of these methods in the culture and maintenance of virus organisms of smallpox, fowl pox, encephalomyelitis, and infectious bronchitis is a reality, and vaccines have already been manufactured from such cultures with gratifying results. Tissue culture work bids for other important fields of study, such as

physiology, anatomy, medicine, surgery, biology, bacteriology, viriology, and immunology.

Having been a student and associate of Doctor Carrel for many years, Doctor Parker, in his book, "Methods of Tissue Culture," has assembled in a concise manner most of the general practices in Doctor Carrel's laboratory, and has placed others within the reach of those who are interested in this fascinating subject. The most recent advances in tissue culture technic and the new fields of application have been carefully added.

The reviewer, even with his limited experience in this line of work, can attest to the thoroughness of the Carrel technic. At the Kaiser Wilhelm Institute für Biologie he used with success practically the same methods and procedures presented in this book. A culture of a tumor has been kept growing in that institution for the past 30 years. The study of the physiology, anatomy, growth, and the causative factor of tumors has taken a grip on the world scientists of today, and the method of tissue culture is being applied in tumor investigations with greater intensity than ever before.

The histology and micro-photography of growing tissues in culture, are very essential in the various applications of tissue culture not only from the standpoint of recording results, but also in interpreting intra- and extracellular changes in the growing process in the normal and abnormal state. These points are well taken up in the book in accordance with the more recent methods.

A most recent and valuable addition to the technic which may revolutionize anatomical or organic studies is that presented by Col. Charles A. Lindbergh in the culture of whole organs. Were this practicable, the progress of the disease processes in a given organ could then be ascertained with precision and thus solve the intricacies of morbidity. This new phase of the technic will no doubt receive careful study and verification by many workers.

Of great interest is the carefully prepared list of sources or references on the various fields of application. Within the limits of a book of less than 300 pages all the detailed sources can hardly be accommodated. Doctor Parker also gives comprehensive data on the subject of growth measurement, which is only lightly treated in other references of this nature.

The culture of adult tissue has been rather a difficult feat in many instances, but the book contains some enlightening directions to accomplish this successfully. The effects of X-ray, sen-

34494——8

sitiveness to their biological factors, tissue allergy, and immunity in vitro are carefully treated. The text ends with a selected list of references pertinently arranged.—T. T.

Financing Agriculture. By L. J. Norton. Danville, Illinois, The Interstate, 1938. 326 pp., illus. Price, $2.75.

This book is easily understandable by students and researchers in farm management, agricultural economics, and banking. It is intended as a textbook or reference for students in farm finance. It is an excellent guide for bankers and those who plan to set up efficient credit systems for financing agricultural activities, such as storing and distribution of farm products and financing coöperative associations. The book may also be of interest to legislators in formulating national policies relative to financing agriculture, rehabilitating the financial condition of the farmer during financial and business depressions, and aiding the low-income tenant farmer to acquire a farm. It is a good manual on the business aspects of farming, for it provides individual farming financing programs, and contains explanations on the wise use of credits, when to borrow and to pay loans, and when to keep and to sell farm products most profitably. The book suggests to lenders and borrowers a sound repayment program.

The author discusses the disadvantages of using capital borrowed from merchants, individuals, and private credit institutions. He gives a description of the United States Farm Credit Administration with a capital of nearly $610,000,000 as an efficient system of financing American agriculture, which other countries, especially the Philippine Commonwealth, may adopt for financing agriculture.

The author has presented a more or less complete treatise on financing American agriculture; it could have been better, however, if the economic root of the agricultural problems or the evolution of financing American farmer from the beginning to the Farm Credit Administration had been included and treated in one chapter, so that the student, scholar, legislator, financier, and others could trace the historical background of the different stages in aiding the farmers of the United States. A chart showing the sources and means of credit open directly or indirectly to the producers of agricultural products would also be very helpful, especially to students and researchers in agricultural economics. The author concludes his book with an index.

—R. M. P.

Mental Health Through Education. By W. Carson Ryan. New York, The Commonwealth Fund, 1938. 315 pp. Price, $1.50.

This book presents a detailed critical analysis of the widespread failure of classroom teachers to guide the emotions and mental attitudes of children. The criticisms, however, are directed mainly at the teacher-training schools which do not provide instruction on mental health. The author spares none in his attack, not even the most venerable and renowned of universities, colleges, and normal schools. He pleads for a reëxamination of teacher-training courses and methods, and advocates the Freudian philosophy and principles. He believes that psychoanalysis and modern psychiatry offer much saner help in school problems and problems of personality than the traditional psychologies.

Among the current educational practices which the author believes interfere with efforts to individualize education and to meet the needs of the children are grades and promotions, recitations and home work, examinations and marks, and discipline. In place of these he recommends projects, and accumulation for every individual youngster of all possible information regarding his life for the purpose of determining how best to help him.

It is in the administrative machinery, the author points out, that some of the most serious dangers to mental health in the schools lie. Highly organized systems are a threat to all efforts to make the individual child and his needs and possibilities the basic concern in education. To carry out its mass of activities from petty correspondence matters to major problems of finance, the administrative machinery overlooks those that concern human beings whether they be teachers, employees, or pupils.

Although the author is severe in his criticisms, he devotes more than half of his book to constructive procedures being done along mental health lines. He describes in some detail several movements for better education of teachers in which major emphasis is given to mental hygiene and personality development. Among the services which he should like to have a regular part of schools are: the visiting teacher, the child-guidance clinic, the school psychiatrist, the school psychologist, and the remedial or adjustment teacher.

The later part of this book is devoted to discussions on the limitations of mental health progress because of family, social, economic, government, religious, and cultural conditions. The book ends with a plea for a radical revision of educational philo-

sophy and methods for the sake of good mental health for children. To that end, the author believes, teacher-preparation schools, the curriculum, and educational administration will have to be enriched and humanized.—M. E.

Twenty-five Years of Health Progress. A Study of the Mortality Experience Among the Industrial Policyholders of the Metropolitan Life Insurance Company 1911 to 1935. By Louis I. Dublin and Alfred J. Lotka. With the Collaboration of the Staff of the Statistical Bureau. New York, Metropolitan Life Insurance Company, 1937. 611 pp., maps, illus.

The authors present a statistical study of mortality among industrial policyholders of the Metropolitan Life Insurance Company during the quarter century from 1911 to 1935 inclusive, embracing a large and representative sample of insured persons in the United States and Canada. This report shows the extraordinary progress in both the public health and the life insurance business. As one reviews the notable advances made in these 25 years, he is impressed by the increase in the average duration of human life in the group studied. Life duration was extended by nearly 14 years, or approximately 30 per cent of the average span following the development of a planned and concerted program of public-health activity among the insured.

In modifying the attitudes and habits of these millions whose coöperation had to be secured in order to put into practice the medical, public-health, and sociological gains of the past few decades, the company joined its forces with those of public and private health agencies. Joint efforts were exerted to raise health department standards throughout the country, to secure more adequate funds for health purposes, and to arouse public support and interest in new and promising methods of disease prevention and treatment. Thus the past 25 years have witnessed a great change in the health, habits of life, and environment of the American people.

The weekly premium-paying industrial policyholders rose from 8 million in 1911 to 17 million in 1935. The policyholders studied in this report are working people, mostly urban dwellers, in a variety of occupations which impose to a certain extent considerable wear and tear upon their health. It is a matter of common experience that urban mortality runs somewhat higher than rural mortality.

The most striking feature of the health picture has been the rapid decline in tuberculosis mortality. In 1911 tuberculosis

was the leading cause of death in the group studied, but in 1935 it ranked seventh in the list based on deaths at all ages combined. For ages from 1 year to 74 years it occupied the fifth place. The death rate from tuberculosis per 100,000 declined from 242 in 1911 to 56 in 1935 as a result of an active organized campaign against this disease.

The general decline of mortality from each disease mentioned herein is explained by the rapid development of medical science, the improved standard of living, and the better sanitary conditions under which men and women work. All in all, environmental factors, medical progress, and health activities have played an important rôle in producing the favorable health picture of the great masses of wage-earners that was enjoyed only by the well-to-do 25 years ago.

The extensive data accummulated during this quarter century undoubtedly shed much light on the health and welfare of the people. Consequently this volume is a useful source of information for health officers, physicians, sociologists, life insurance officials, and others interested in the development of medical science for advancing the cause of public health. The numerous charts and tables further enhance the value of this book.

—M. Ma. A.

RECEIVED

BEGHIN, P. Le fonds national de la recherche scientifique et l'industrie. Bruxelles, F. N. R. S. 408 pp., illus.

BRONSON, WILFRID S. The wonder world of ants. Illustrated by the author. New York, Harcourt, Brace and company, 1937. 88 pp., front., illus. Price, $1.50.

CRAWFORD, R. Some anopheline pupæ of Malaya with a note on pupal structure. Published by the Government of the Straits Settlements and the malaria advisory board, Federated Malay States. Singapore, Government Printing Office, 1938. 110 pp., illus.

The German Reich and Americans of German origin. New York, Oxford university press, 1938. 46 pp. Price, $1.50.

GONZALEZ ROA, FERNANDO. Chapters on the agrarian question in Mexico (La cuestión agraria) in Las Cuestiones fundamentales de Actualidad en Mexico (Mexico, Imprenta de la Secretaría de relaciones exteriores, 1927). Translated by Gustavo E. Archilla. W. R. Dittmars, Ph. D., Project Supervisor. Translated as a report on Project No. 465–97–3–81 under the auspices of the Works Progress Administration and the Department of Social Science, Columbia University. New York, 1937. 196 pp., mimeographed, paperbound.

HILLS, FRANKLIN G. The technical analysis of ores and metallurgical products. 2d ed. New York. Chemical publishing co., inc., 1939. 250 pp., illus. Price, $3.

The horse owner's reference book. Containing information respecting horses and ponies for the year 1939. Issued by the National Horse Association of Great Britain, London. 172 pp., illus. Price, 1s.

Institut international d'agriculture. International bibliography of agricultural economics. Rome. v. 1, no. 1. October, 1938.

KOUMANS, FREDERIK PETRUS. A preliminary revision of the genera of the gobioid fishes with united ventral fins. Lisse, Drukkerij "Imperator" N. V. 174 pp.

MOULTON, HAROLD G. Income and economic progress. Washington, D. C., The Brookings institution, 1935. 174 pp., illus.

SAXON, EDGAR J. Soil and human health: A call to action. Substance of an address given to the Nature Cure Conference at High Leigh, Hoddesdon, Herts, on November 19th, 1938. London, The C. W. Daniel company, ltd. 8 pp. Price, 3d.

ERRATUM

VOLUME 69

Page 469, line 9 from the bottom, *for* invalid *read* valid.

INDEX

A

O